Electrical Review

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ELECTRICAL EDUCATION.

Just as it is beginning to be realized that education in general is one of the most important features of the life of the individual and of the nation, so, in the more restricted field of the engineering professions, it is seen that the education of young engineers is a subject which should be given most serious and careful attention, and to which should be brought the best experience possible. The future of the professions is bound up in that of the students who are now in schools or preparing to enter.

The teaching of electrical engineering has been undertaken in the United States by a considerable number of colleges, universities and technical schools with more or less success, but there does not seem to be entire accord of opinion regarding what the curriculum should be, or, indeed, what constitutes an electrical engineer. We see young men turned out from some institutions with a fair amount of book knowledge and some scraps, possibly, of laboratory experience, but unable to take their places even as novices in the profession. From other schools come men equipped practically to enter upon their careers, and able to earn their livings from the start. But it is by no means certain that these men have the variety of training that will result in the greatest success hereafter. The work of the world will be done by the engineers who know how to think. It is teaching them how to think, not filling them with facts and training them in arts and handicrafts, that is the true business of an institution for the teaching of engineering.

It is with pleasure that we can give, this week, a very full description and illustrations of the electrical engineering schools of McGill University, in Montreal, Quebec. The equipment and the method of education pursued at this institution illustrate the point referred to above. The object and aim of its electrical engineering department is to train the students passing through it in the art of original thought, and to equip them with a mental furnishing that will be useful to them afterward. When a young man leaves college with an engineering degree he should be ready to learn his business. Far too many young men think at this point that they have already learned all that there is to know, but of this idea the realities of everyday life soon disabuse them. If the student's training has been of the right sort every piece of work that he does, or sees done, every process and method that he encounters, every new piece of machinery or apparatus, is understood and fits into its place in his mental picture of the state of the art, so that in an amazingly short time he has acquired wisdom that comes of experience, and the knowledge that is born of contact with things. Not until then is he fully equipped for the exercise of his profession.

While, in the United States at any rate, the profession of electrical engineering is well filled and while in it competition and concentration of manufacturing interests according to the usual laws of business, has made the rate of remuneration small, still, there is room in the profession—near the top.

THE TRANSPACIFIC CABLE.

Among the several important matters now under consideration by Congress, none is more directly of interest to the whole business community than the immediate construction of a cable across the Pacific Ocean. It needs no argument to prove the necessity for such a cable, whether it is regarded from the military or the commercial point of view. The colonization and pacification of our island possessions will proceed rapidly or slowly, according to the goodness of the means of communication and transportation between them and the mainland. The business interests that will be affected, and we believe affected for the better, by the opening of Eastern markets, are urgently demanding the construction of a cable, while military and naval commanders have recommended it for years past as an important part of the offensive and defensive equipment of the nation.

While a cable owned by foreigners would be, perhaps, equally as valuable for business interests as an American cable, it would certainly be of no value in time of war. The strategic value of a transpacific

cable depends almost entirely upon its ownership and upon the protection that may be given by fleets or armies to its landing points. The Utopian idea has been suggested that cables may be neutralized and kept open in time of war, but everybody who knows anything about warfare and its actual conditions knows that cable cutting will play an important part in military and naval operations hereafter. We need an American-made and American-owned cable from the United States to Japan and China, by way of the Hawaiian Islands and the Philippines; indeed, we will probably need two of them within a few years. We need the landings of this cable to be in fortified places on American soil. The need for it is instant and so urgent that its construction should receive the immediate and careful attention of Congress. Whether it be constructed by the government as an auxiliary for the naval or army service, or whether by private parties in close relation with the government, makes no particular difference; but we do not want a neutralized cable or a cable landing on foreign or unprotected points. While war is perhaps less common that it was once, the disarmament of the world has not begun, and it takes no training in military matters to see that a cable might be worth almost as much to us as a fleet, under certain circumstances. The opening of China will be one of the greatest steps in the material progress of the world that has ever been undertaken; that it will be peaceable nobody who knows the conditions in the East will believe. There will be war and there will be trade in the East, and for both these the cable is necessary. It will be a tie binding more closely to us our friends in Hawaii, and an instrument of civilization and teaching for our newly-acquired populations elsewhere.

We must not only have the cable, and that quickly, but we must also make it and lay it. There is no use to mince words. Until the United States has within its boundaries a full-fledged plant for making deep-sea cables and with experience in that particular department, it will be handicapped in the struggle for commercial supremacy. We have excellent plants, though none of them has built a long deep-sea cable, but we sadly lack experience, and the transpacific cable will be a good place to get it. There is not a cable ship in the world flying the American flag.

THE RAPID TRANSIT SUBWAY.

Gratifying progress is being made on the construction of the Rapid Transit Subway, in New York city, and from present appearances, unless some unexpected obstacles are encountered, the tunnels will be ready for the installation of the traction system in about five years.

To one looking back over the growth of New York city during the last five years, and endeavoring to understand the conditions that will surround living in the metropolis in 1905, it seems evident that the tunnel will have from the very first an enormous patronage. Its capacity will be considerably greater than that of the elevated railway, since it will have double tracks for express trains and can operate these and the locals at the same time with considerably greater ease than can the elevated railway with its triple-track structures. Notwithstanding the excellent promise for the future that is exhibited by the progress of the work on the Subway, five years is a long time to wait for an improvement so urgently demanded. New York city, by its peculiar configuration, is perhaps more dependent on intermural transit than any other city in the world. Distances on Manhattan Island between the quarters in which people work and those in which they sleep are so great that really rapid transit is demanded to prevent the spending of a considerable portion of the lifetime of the public on street cars and trains. The growth of the city, while it has been very great, has certainly been hampered in no small degree by the lack of flexibility of the existing means of transit which are now working at their limit of carrying capacity. Of course, the electrification of the elevated railways will do some good, but while we are to have this next year and may expect some amelioration from it, the rate of increase of the city is such that by 1903 the electric trains will be as much crowded as the steam trains are now. One naturally seeks for some suggestions that will remedy the grevious condition of things that is now so apparent. We need rapid transit to come more rapidly than it can by means of the slow-growing tunnel under our streets. One suggestion that has been made several times, and which seems practical, is to double-deck the elevated railways and put up express tracks at a higher level. This could be done in much less time than it will take to complete the tunnel, and, with electric traction, there can be no doubt that this system of railway would be more popular than that underground. Another suggestion has been to turn over one of the avenues running north and south, upon which the elevated railway now stands, to railway traffic altogether, and by enclosing the street under the structure and providing suitable cross-overs for cross streets, to allow surface cars to be run on existing tracks at high rates of speed. This project would be more difficult in execution than double-tracking the railway, and would seriously interfere with the already overcrowded traffic facilities of our New York streets.

Something must be done, and done quickly, to do away with the trammels that bind us and restrict our proper growth. It does not seem reasonable that we should wait five years, or possibly longer, for a genuine betterment.

The next two months will be the season for considering electric railway building plans, and the several months following will be active with the construction of innumerable railway lines throughout the United States. If one may be permitted to draw an inference from the evident tendencies of business affairs in this country, and the peculiar situation of electric railroading, it seems safe to predict that the Summer of 1901 will not pass without the consolidation of innumerable lines of trolley road into long trunk line systems. For example, a trunk line of electric railways between the business centres of New York and Boston may most easily be made by the acquisition of some dozen or more at present disconnected links, and the building of less than seventeen miles of new track. That the next year will see such things done is self-evident to any one

who knows anything about the electric railway business in the United States. What its effect upon the railways will be is perhaps not so evident, still it is impossible not to think that it must have the effect of driving the main line trunk railways now operated by steam to the adoption of electrical equipment for the operation of swiftly moving trains making frequent stops, in order that they may compete with the electric service that threatens to take away from them the most profitable part of their passenger business. The situation is one that is full of interest for the electrical engineer and even more so for the capitalist who has knowledge and courage. Looking at the situation broadly it seems as if this threatened revolution in railway matters would furnish us within the next two or three years with more work than the present equipment of electrical manufacturing establishments can undertake.

Some remarks in these columns a few weeks ago concerning the value of a telephone exchange connecting the various parts of a long through express train, suggested to a correspondent the idea that a valuable addition to such service would be connections with the local telephone service, to be made and maintained while the train was stopped at stations. In this way the passengers would be enabled to communicate by long-distance telephone.

The really astonishing thing about this suggestion is not at first evident. We are so accustomed to the marvels that have become part of our daily lives through the telegraph and the telephone that we do not know how dependent we are upon such things until we become exiles of an hour in traveling upon a railway train. Our dependence on electrical means of communication has grown practically absolute, and to be deprived of them even for a few hours is like losing a sense. The modern man of business, when out of touch with telephone and telegraph, feels a curious sense of isolation. He is accustomed to have the world of his business affairs within touch, as it were, and within sound of his voice in actuality. Suppose for a moment that the entire telephone service of New York city should be stopped some fine morning. Probably neither earthquakes, pestilence nor war could so quickly stop the wheels of commerce or create such fearful confusion as would instantly result.

While our esteemed contemporaries of the daily press occasionally need to be taken to task for publishing false science, and thus aiding charlatans and swindlers, it is very gratifying to know that instances of such publication are becoming rarer. A few newspapers of the better class have recognized the importance of scientific and technical matter, and the greater importance of having this correct and orthodox, and have employed competent persons to supply such articles or edit them. It is hard to state justly the importance of the newspaper as a means of education. It seems that in it, more than anywhere else, accuracy and correctness should be essential, and it looks as if some of our larger American dailies are learning this fact. The newspaper is the text-book of the average man; from it he learns most that he knows, and from it he gains ideas which materially affect his destiny. If, therefore, scientific subjects are touched upon at all in the ordinary newspaper, it should not be forgotten that a false statement or a heretical scientific doctrine may work very great harm and cause much trouble. For instance, the newspapers materially assisted in gulling silly people to invest their money in a method to extract gold from sea-water. If a good newspaper had investigated this scheme and shown it in its true light it would have saved a great deal of money to a number of people who lost money through their credulity.

Passengers entering or leaving New York by the Grand Central Station are congratulating themselves and the managements of the railroads centering there upon the great improvements that have recently been made in that structure. Much has been done to improve matters at the terminal, but the congratulations that are now heard would swell into pæans of delight and satisfaction on the part of the commuters and other travelers if the railway companies would only announce their determination to put electric traction in the Fourth avenue tunnel. Some of these days, somehow, somebody will convince the managements of the loss they are now incurring by operating steam locomotives in these tunnels, and they will believe the truth. Lately they appear to have resembled the board of managers of the London Underground Railway, who solemnly determined a year or two ago, after having spent years in consideration of the matter, to experiment with electric traction and see if it would work! It is stated that they are still experimenting, while the enterprising people who went ahead and built the "two-penny tube," or Central London Underground Railway, and equipped it with American electric-traction apparatus, are getting all the business. There is a good and worthy moral in this story.

In the message which President McKinley recently sent to Congress he recommends a reduction of the war tax by the sum of $30,000,000 annually. It is greatly to be hoped that when Congress undertakes this reduction, it will commence with the tax on telegrams and telephone messages. Free intercourse of written and spoken words between the people is absolutely necessary to all kinds of business. The tax on telephone messages has been paid by the telephone companies generally, but the annoying one-cent tax on telegrams has been paid by the public, and has been the occasion of unbounded annoyance, trouble and profanity ever since its imposition. It is highly desirable that Congress shall see its way clear to remove these taxes from means of communication that should be helped and encouraged in every way by the government and of relieving the public from annoyance and the telephone companies from a considerable burden of expense.

What has become of the various schemes for vacuum-tube lighting that were exploited some few years ago? One of these, as we remember, almost worked, and results were obtained which seemed certainly sufficiently valuable to encourage further and more careful study of the subject. The production of "cold light" has been a sort of chimera or scientific dream for the last decade. Inventors of prominence and promise—mostly promise—have attacked the formidable problem, and have made some of the most astonishing claims and statements that have appeared in the history of electrical invention, but of their results there is nothing in evidence.

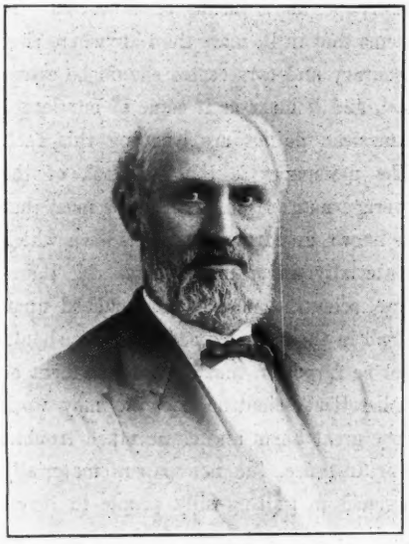
Electrical Engineering at McGill University, Montreal, Canada.

Equipment and Facilities of the Great Canadian Scientific School—The Finest and Most Complete Electrical Engineering Laboratories in the World—Courses of Instruction and Instructors.

BY CHARLES T. CHILD.

Few countries in the world are so blessed with natural resources as is Canada. With thousands of miles of virgin forests, with innumerable cascades furnishing abundant and widely distributed water-power, with ores and minerals of nearly every sort that is of value in the arts, and with excellent and growing transportation facilities, the country has, unquestionably, a high destiny. It is in no small degree through the appreciation of this fact by Canadians that the superb engineering equipment of McGill University at Montreal has grown so rapidly and become so complete.

The resources of Canada are such that its industrial development largely depends upon the work of the engineer. While it possesses the great wheat-growing regions of Manitoba and the Northwest Territories, large and prosperous farming districts in Ontario and elsewhere, large parts of the country are, by reason of climate and geological conditions, unsuited for agriculture. But, and in these parts especially, its mineral wealth and water-power invite the development of mines and manufactures of all sorts, and afford perhaps the most abundant opportunities existing to-day for the application of engineering skill. Perhaps a knowledge of these facts, though probably they were but dimly seen in the past, may account, in some measure, for the liberality of the foundation of the institution with which this paper deals, and the support which it has lately received. Founded in 1821, McGill University instituted a course in engineering in 1878, but can hardly be said to have become a centre for engineering instruction until about 10 or 12 years ago. During the last decade the department of Applied Science has grown and enlarged and its work has increased by leaps and bounds; and to-day there is probably no better equipment in the world for its purposes than this faculty possesses. The ability to do this has resulted largely from the splendid endowments of Sir William C. Macdonald. To him the University owes the reequipment of its electrical laboratories, and its facilities for teaching and research in that and other departments. Sir William Macdonald was born in one of the Scotch settlements on Prince Edward Island and was educated at Charlottetown in that province. Since 1854 he has been in business in Montreal, having amassed a large fortune in the manufacture of tobacco. Among his gifts to McGill University are the buildings, with their equipments and endowments, for the teaching of engineering, physics, chemistry and mining. In addition, he has founded numerous pro-



Sir William Macdonald.

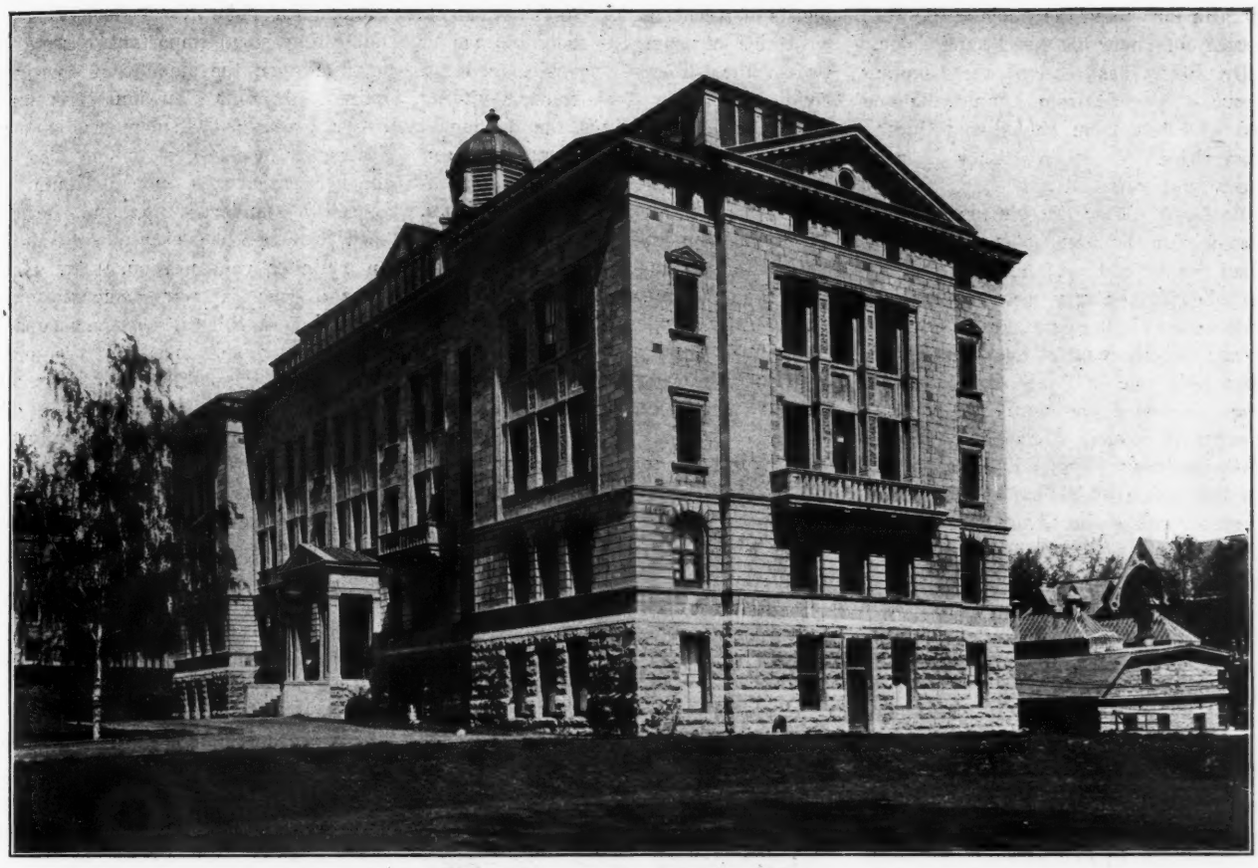
fessorships and scholarships, and has given many sums of money for general purposes. His benefactions to the University aggregate over $3,000,000, and he has also erected, at his own cost, model training schools in the principal centres of Canada.

Another benefactor of the University, whose name should not be omitted, is Lord Strathcona and Mount Royal, formerly Sir Donald Smith, the governor of the Hudson Bay Company and the president of the Bank of Montreal. To the University Lord Strathcona has given medicine buildings and chairs in medicine and biology; the Royal Victoria College, a residential hall for the women students of the University; and in collaboration with Lord Mount Stephen built and endowed in Montreal the splendid Victoria Hospital.

Lord Strathcona is one of the many Scotchmen who have risen to high position in Canada. Born in Morayshire, Scotland, young Donald Smith came to Canada in the service of the Hudson Bay Company, and became, in 1888, governor of the corporation. He was a special commissioner in the inquiry concerning the Riel rebellion, while his conspicuous services in the organization of the Canadian Pacific Railway and the construction of that line caused him to be chosen for knighthood. More recently, since his many public charities and bequests, Sir Donald Smith has been elevated to the peerage, under the title of Lord Strathcona and Mount Royal.

The University is composed of faculties of Arts, Applied Science, Law, Medicine and Comparative Medicine. The faculty of Applied Science comprises departments of electrical engineering, civil engineering, mechanical engineering, mining engineering, surveying and geodesy, and practical chemistry. Of this faculty, Professor H. T. Bovey is the dean.

Professor Bovey was born in Devonshire, England, March 7, 1852. His primary education was received at a private school, after which he entered Cambridge University, where he competed for and obtained an open scholarship. On graduation he took a high place in the mathematical tripos and shortly afterwards was made a fellow of Queen's College. Adopting the profession of a civil engineer, he joined the staff of the Mersey Docks and Harbor Works and was in a short time appointed an assistant engineer on this work, in which capacity he had charge of some of the most important structures then in progress. In 1877 he came to Canada on his appointment of professor of civil engineering and applied mechanics in McGill University. At that time the engineering courses in the University were managed as a branch of the faculty of arts and were without buildings or equipment. The following year, however, a department of applied science was constituted with Professor Bovey as dean, and to his management and advice the science department owes its splendid development. The magnificent engineering buildings were planned and equipped



THE MACDONALD ENGINEERING BUILDING, MCGILL UNIVERSITY, MONTREAL.

ONE OF THE LECTURE ROOMS IN THE ELECTRICAL DEPARTMENT OF MCGILL UNIVERSITY.

by Dean Bovey and the whole of the work carried out under his direct supervision.

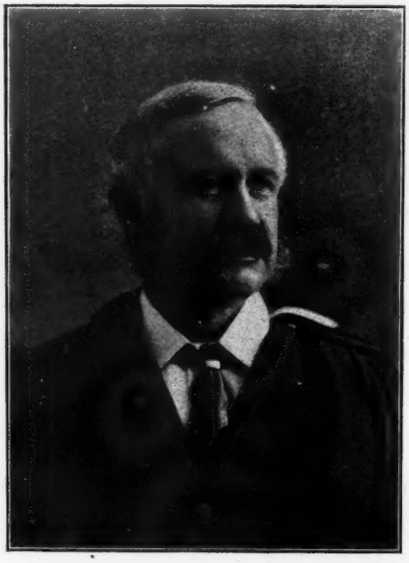
Dr. Bovey has received the honorary degree of D.C.L. from Lennoxville and that of LL.D. from McGill and Queen's universities. He is the author of many papers and works.

Professor Bovey was intimately connected with the foundation of the Canadian Society of Civil Engineers and held the office of honorary secretary-treasurer and member of the council for many years; he was vice-president of the society in the years 1896 and 1897, and in the present year was elected president. He is also a member of council of the Institution of Civil Engineers, England; a member of the Institution of Mechanical Engineers, England, and of the Liverpool Society of Civil Engineers, of which society he was one of the founders; an honorary member of the National Electric Light Association of the United States; a fellow of the Royal Society of Canada, of which society he was president of section 3 in 1896. He was vice-president of the mechanical section of the British Association in 1897. He was also the founder of the Montreal Sanitary Association, which has revolutionized house plumbing in that city.

Instruction in any of the engineering departments is maintained through a curriculum covering four years. Of these the first two years are spent in the study of physics, chemistry, mathematics, drawing, the use of tools in the carpenter, pattern and machine shops, smithy, etc., and the last two years are specially devoted to the particular branch of engineering in which proficiency is sought. The aim of the instruction given in all the engineering departments is to produce scientific engineers, equipped with thorough understanding of the principles of their profession, and with working knowledge of the sciences underlying it, yet without actual technical training which, it is wisely insisted, can be had only in actual experience and through work outside of an institution of learning.

McGill University is pleasantly situated in large and very beautiful grounds at the foot of Mount Royal, and in the central part of the residential section of the city of Montreal. The buildings are arranged about three sides of a square, the arts building forming the central half of the architectural scheme, while upon each side are grouped the other buildings of the University. On the one side is the Redpath Library and Museum, in which is an exceedingly good collection of minerals, due to the labors of the late Sir William Dawson, once principal of the University, and one of the most distinguished geologists of recent years. On the same side with this museum are the buildings of two of the affiliated theological colleges. On the other side of the central building are the medical buildings, the Macdonald physics building, the chemistry and mining building, and the engineering building, which are illustrated in these pages. The gymnasium and the veterinary college are outside of the University grounds.

It is not improper here to say a few words of Dr. William Peterson, the principal of the University. Dr. Peterson was born in Edinburgh in 1856, and during his early manhood acquired many scholastic honors in the study of the classics. In 1882 he was unanimously appointed principal of the University College, at Dundee, and in 1895 was invited to fill the position of principal of McGill University, but lately vacated by the death of Sir William Dawson.



PROFESSOR H. T. BOVEY, DEAN OF THE ENGINEERING FACULTY.

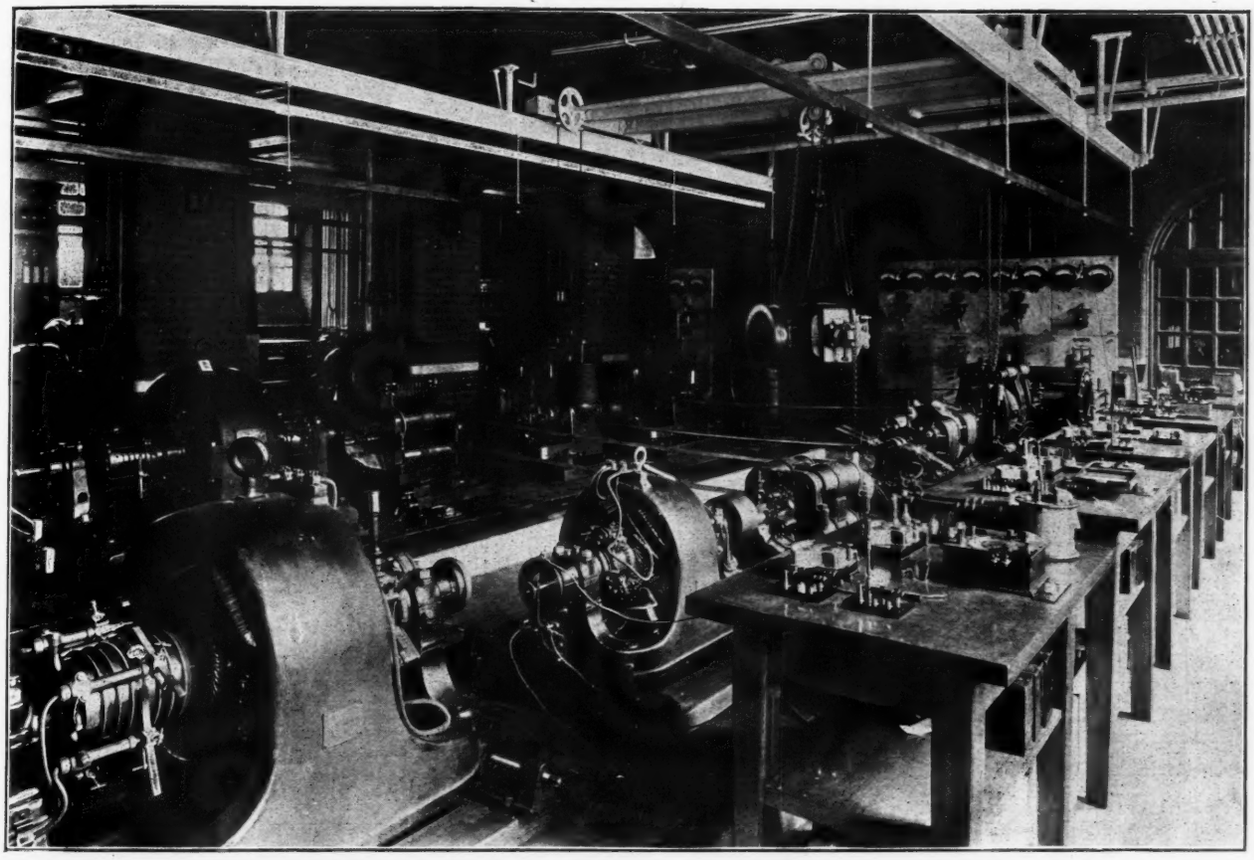
Before proceeding to describe in detail the work of the electrical engineering department, it may be well to give a brief idea of that of the affiliated engineering departments and the facilities in the scientific courses through which a student comes up to his work in electricity proper.

The department of physics is directed by Professor John Cox and Professor E. Rutherford. Professor Rutherford is well known from his brilliant work at the Cavendish Laboratory of Cambridge University, in England, and at McGill, on current conduction in gases under various conditions, his work with Professor Thomson, and his exceedingly brilliant researches on uranium radiation and induced radioactivity in metals and other substances by emanations from thorium compounds. The Royal Society is just publishing some important observations by him upon the amount of energy required to produce an ion. His predecessor, Professor Callendar, who is now at University College, London, also did much research work upon platinum thermometry, standards, etc., and, together, with Professor Nicholson, also of McGill, on cylinder condensation. Dr. H. A. Barnes, who is now demonstrator in physics at McGill, will be remembered for his classical determination of the specific heat of water at different temperatures and his work on standard cells. The equipment of the physics laboratory is probably as perfect as that of any in the world, if it may not justly claim to be the finest; and the fact that it is in regular use is one in which the University authorities take much pride.

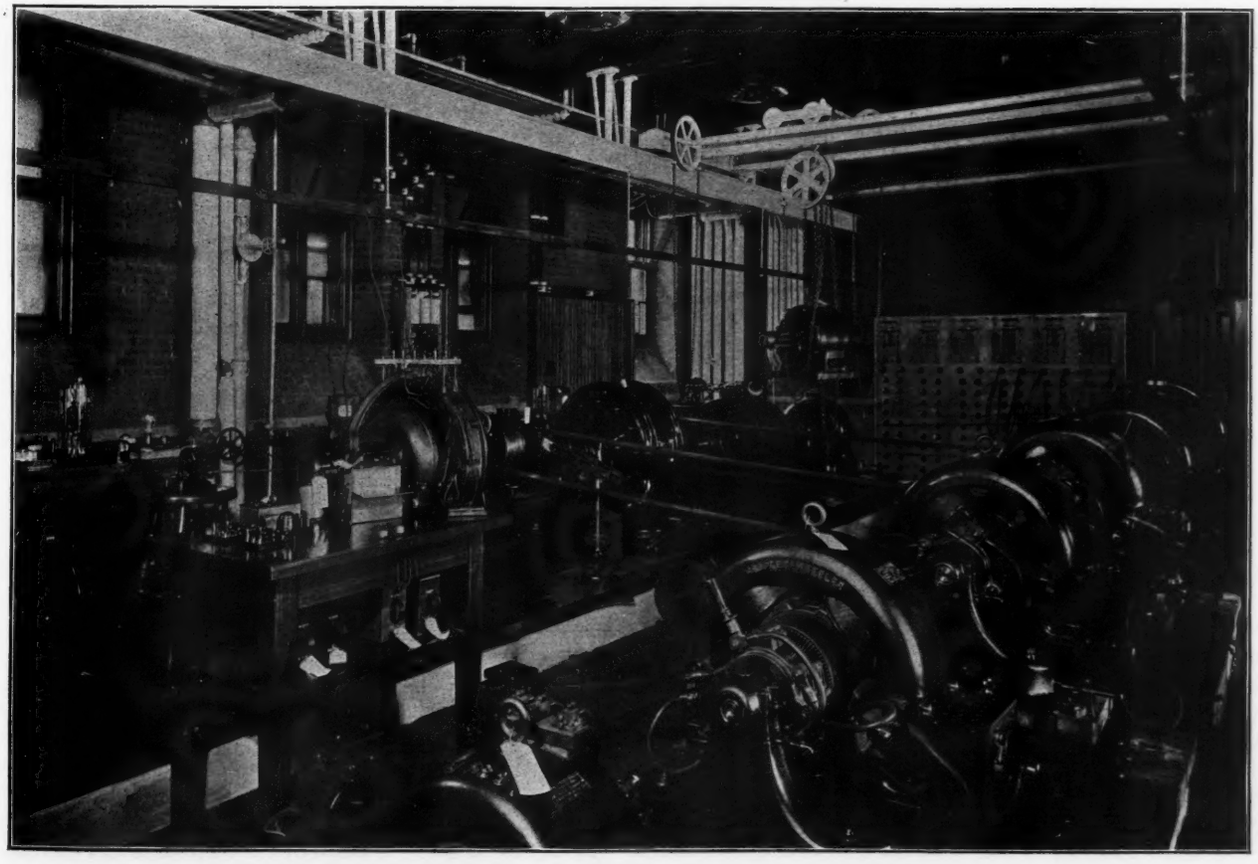
The chemistry and mining department is under the charge of Professor B. J. Harrington and Professor J. W. Walker. The latter was connected for some years with Professor Ramsay in his elaborate researches on new atmospheric gases, such as argon, crypton, etc. The chemistry building is very completely equipped with apparatus for research work and demonstration, and recently, to meet the demand for instruction in mining, a department in that branch of engineering has been equipped and generously endowed by Sir William Macdonald. Dr. J. B. Porter, formerly of the Columbia School of Mines, was placed in charge, and it has already effected close relations with the mining industry of Canada with great mutual benefit. The mechanical engineering laboratories are most elaborately equipped. The laboratory for testing the strength of materials is fitted with Emory and Buckton testing machines, and every appliance necessary for all varieties of tests of this character. The hydraulic laboratory has probably the finest standpipe in the world, and every variety of flumes and weirs and other apparatus necessary for the test of hydraulic motors of all kinds. At present an elaborate series of tests is under way concerning the flow of water in pipes, the methods invented by Dr. Bovey being in use.

The mechanical engineering department proper, under Professor R. J. Durley, has an elaborate equipment of experimental engines of all kinds—steam, gas, oil, hot-air, etc., being represented by their various types. It is also well fitted with numerous types of boilers, and its equipment is of the same character as that of other cognate departments of the University.

The electrical department is under the charge of Professor R. B. Owens, Mr. L.



THE DIRECT-CURRENT DYNAMO LABORATORY, MCGILL UNIVERSITY.

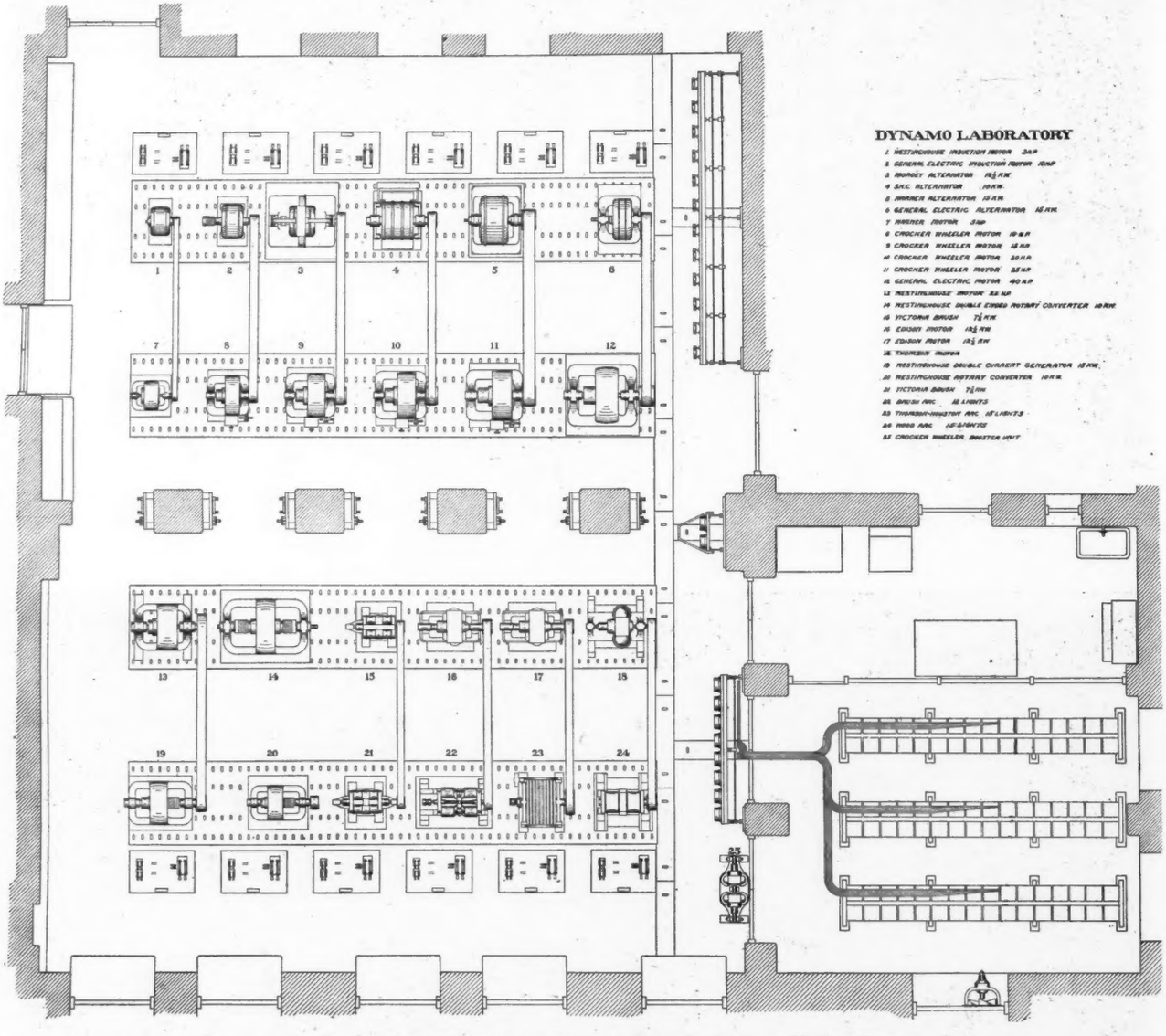


THE ALTERNATING-CURRENT DYNAMO LABORATORY, MCGILL UNIVERSITY.

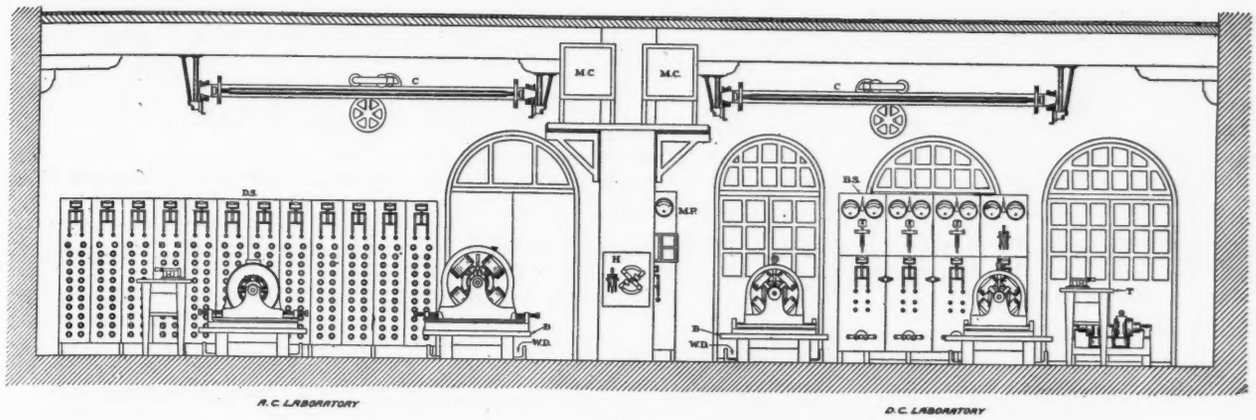
H. Herdt being his assistant, and Mr. J. W. Fraser instructor. There are also two laboratory attendants, a mechanician, and a complete service staff.

Professor Owens is a native of Maryland, and was educated in the Johns Hopkins University. In that institution he studied mathematics and physics, and leaving it commenced electrical work in New York city. Afterwards he constructed, and subsequently superintended, the electric lighting station at Greenwich, Ct. Studying the meanwhile, in 1891 he received the post-graduate degree of electrical engineer from Columbia College. He became shortly afterwards adjunct professor of electrical engineering in the University of Nebraska; in 1894 he was made full professor of electrical engineering and in 1895 he took full charge of the department of electrical and steam engineering in that institution. He was a member of the International Electrical Congress of 1893, and a judge of awards in electricity at the Columbian Exposition of the same year. He is a member of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, as well as of other similar societies.

The electrical laboratories are five in number, as follows: A direct-current dynamo laboratory; an alternating-current dynamo laboratory; a laboratory for special investigations; a high-tension laboratory, and a standardizing laboratory. In addition to these, the institution has a complete service plant and battery-rooms in the basement of the engineering building. These are well shown in the accompanying illustrations. The service plant proper consists of five boilers, two of the Babcock & Wilcox type, one of Professor Nicholson's design, one a locomotive boiler, and another used for steam heating. These supply steam to four generators, arranged as is well shown in the plan and sectional view of the service plant, and consisting of the following parts: A horizontal side-crank engine, built by the Robb Engineering Company, and direct-coupled to a 75-kilowatt direct-current 125-volt generator, built by the Crocker-Wheeler company; one horizontal central-crank engine of the Goldie & McCullough Company's make, coupled directly to a generator of the same dimensions as that mentioned above, built by the Canadian General Electric Company; one vertical central-crank engine, built by Willans & Robinson, of England, direct-coupled to a Siemens Brothers & Company 105-volt 30-kilowatt direct-current bipolar generator; another similar Willans engine is coupled to a 30-kilowatt Mather & Platt generator. In addition to this generating

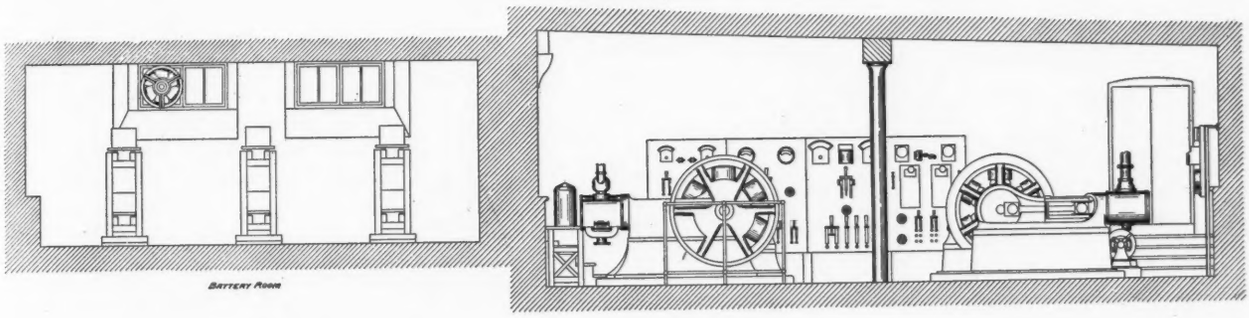


Plan of the Dynamo Laboratories and Storage Battery Room in McGill University.



DYNAMO LABORATORY

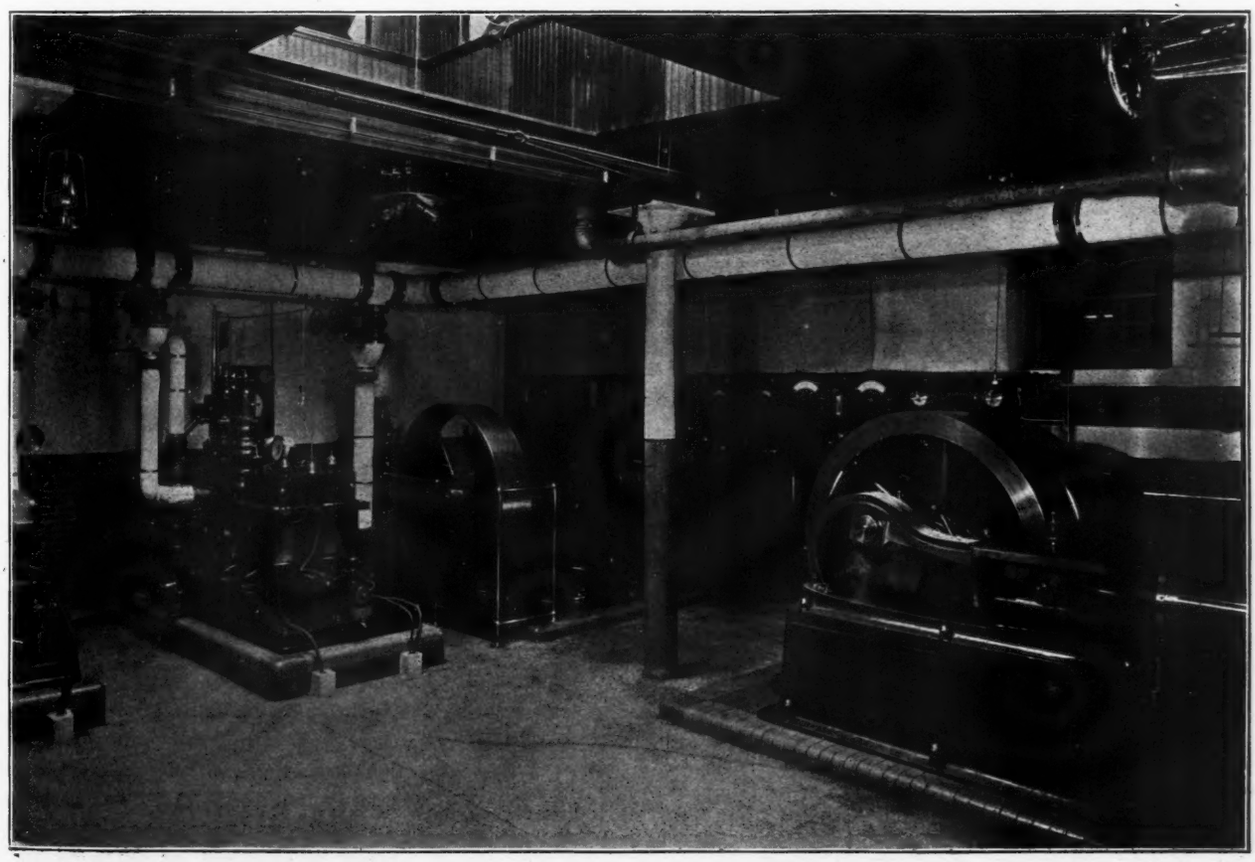
SIDE ELEVATION



SERVICE PLANT

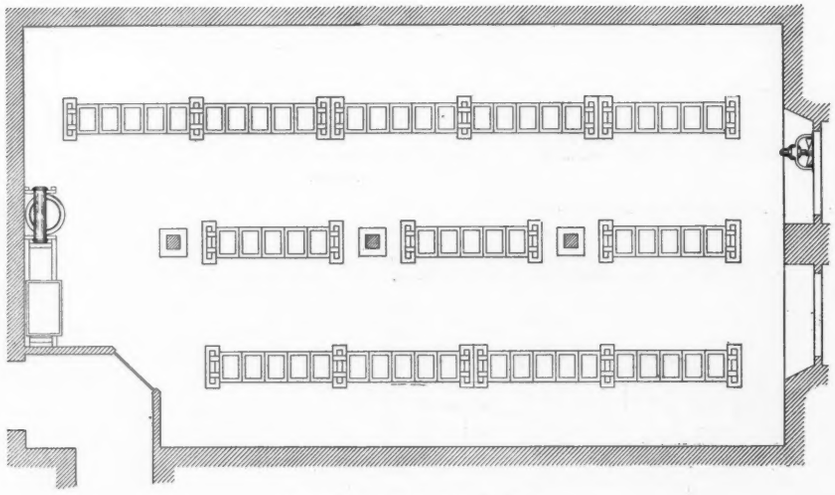
SIDE ELEVATION

SECTIONAL ELEVATIONS OF THE DYNAMO LABORATORY AND SERVICE PLANT, MCGILL UNIVERSITY.



ENGINE-ROOM OF THE SERVICE PLANT OF MCGILL UNIVERSITY.

plant, a booster motor-generator, working from 110 to 40 volts, and with a capacity of seven kilowatts, is also installed. This machine was built by the Sprague Electric Company. In the service plant engine-room there is a four-panel switchboard with instruments, switches, circuit-breakers, and cell-charging apparatus.



SERVICE PLANT BATTERY ROOM

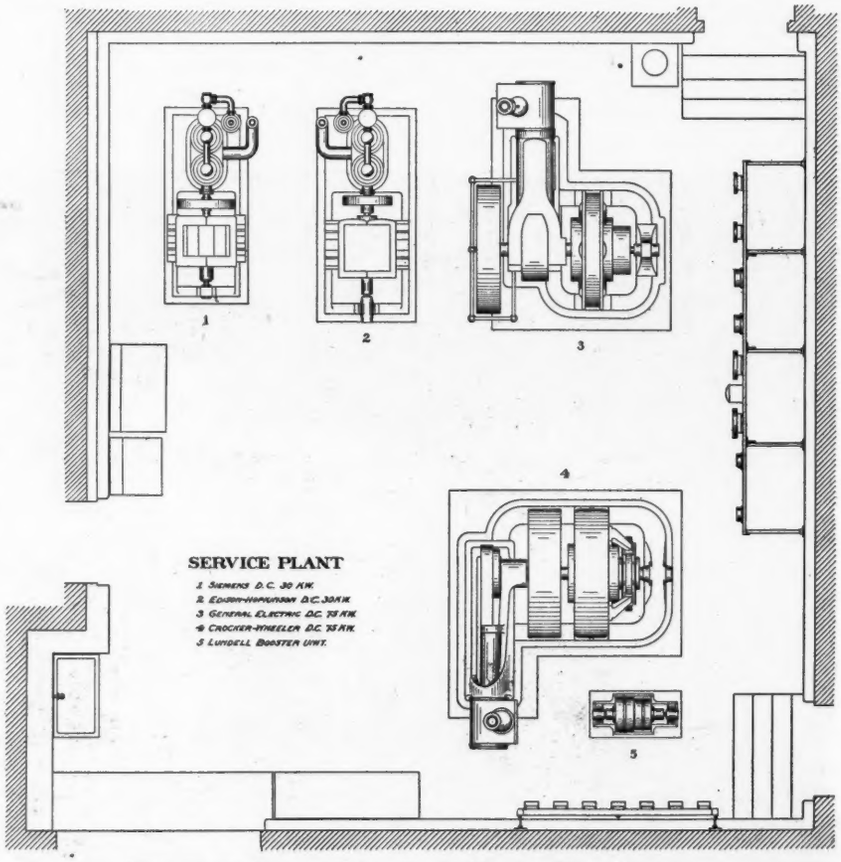
THE DIRECT-CURRENT DYNAMO LABORATORY.

Perhaps the most notable feature of the direct-current laboratory, or at least the feature that immediately impresses one entering it, is that there are no belts in the way, that all of the apparatus is movable easily and quickly from place to place, and that nothing is permanently fastened down, so that any possible combination of the elements present may be made in a few moments and very simply. Before the re-equipment of the laboratory, two years ago, the dynamos were all driven from overhead countershafts. This arrangement was apt to cause fluctuations of load on one machine to become evident as variations of speed in the others. The arrangement now is such that each dynamo is driven by a separate motor, capable of independent speed-control, while a sufficient number of supply circuits are wired through the laboratory to enable this always to be done with a maximum of convenience. The machines that are provided, as may be seen by the list below, are sufficiently large to possess commercial characteristics, yet small enough to be handled with ease and to require a minimum of power for their operation. The equipment of this laboratory is as follows:

One 16-light, 10-ampere Thomson-Houston arc dynamo, made by the Royal Electric Company; driven by a 20-horse-power, direct-current, multipolar motor, Westinghouse Electric and Manufacturing Company.

One 16-light, 10-ampere, Wood arc dynamo, Fort Wayne Electric Company; driven by a 16-horse-power, direct-current, bipolar motor (Edison), Canadian General Electric Company.

One 10-light, 10-ampere arc dynamo, Brush Electric Company; driven by a 16-horse-power, direct-current, bipolar motor (Edison), Canadian General Electric Company.



PLAN OF THE SERVICE PLANT ENGINE-ROOM, MCGILL UNIVERSITY.

One 5-kilowatt, direct-current, motive-power dynamotor, Brush Electric Engineering Company; driven by a 7.5-horse-power, direct-current, multipolar motor (Victoria), Brush Electrical Engineering Company.

One 15-horse-power, 500-volt, multipolar, street railway motor, Canadian General Electric Company.

One 5-horse-power, 110-volt, direct-current multipolar motor, Royal Electric Company.

One 15-horse-power, 110-volt, direct-current, bipolar motor, Thomson-Houston Company.

Two 3-horse-power, 110-volt, direct-current motors (fan type), Sprague Electric Company.

One 2.5-horse-power, 110-volt, direct-current motor, Canadian General Electric Company.

A number of small machines from one-twentieth to one-half horse-power of the following makes: Crocker-Wheeler Electric Company, Sprague Electric Company, Lundell and General Electric Company.

All of the machines are mounted on benches about 15 inches high, these being built of three-inch flooring, laid on 6 by 12-inch timbers, firmly bolted to a concrete foundation. Under each edge of these benches is a concrete wire duct containing heavily insulated supply circuits. At intervals of five feet, each of these supply circuits is tapped to insulated bayonet joint connectors, all of which are appropriately numbered. Any dynamo or motor can be connected at once to any supply or other circuit, or connected up in

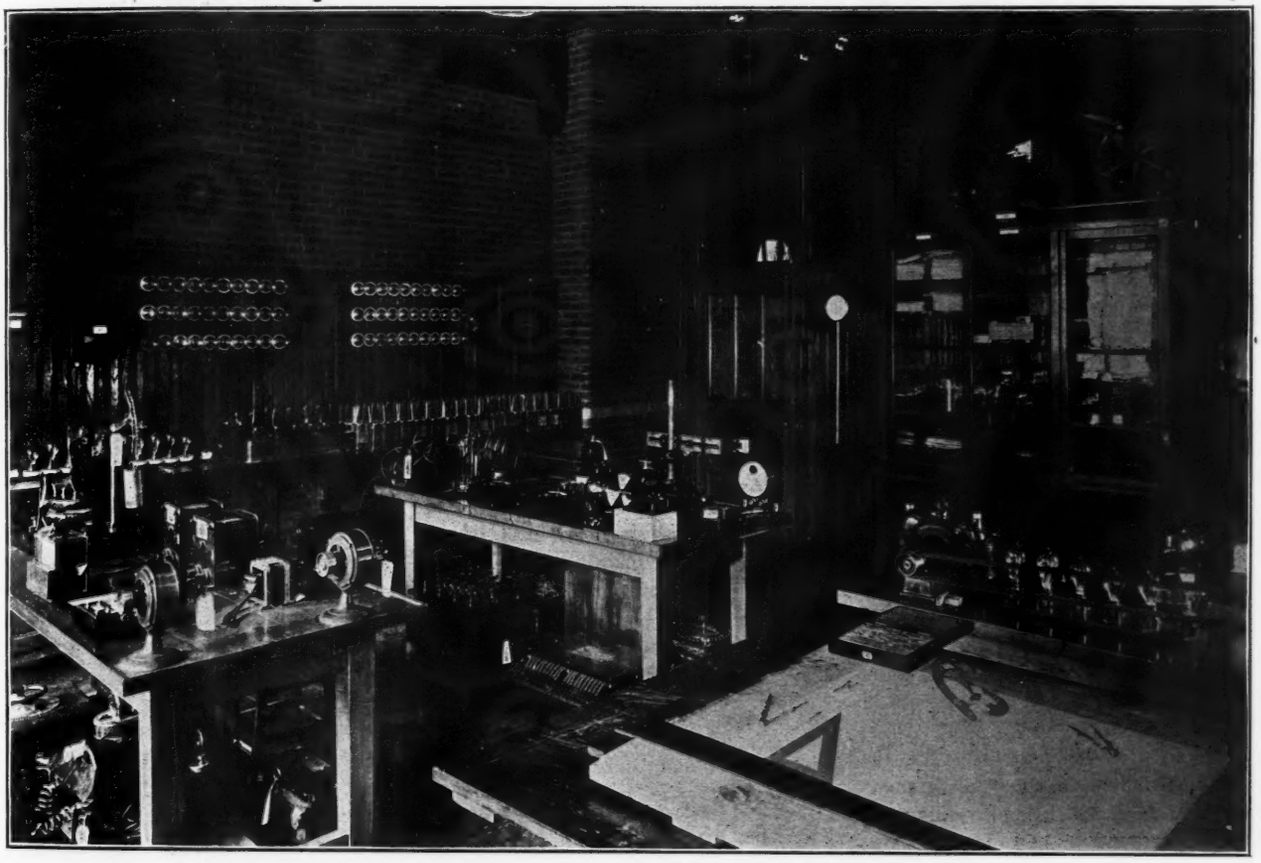
any way that is desired for circulating power tests. The benches are provided with an accurately spaced series of slots, as is well shown in the illustration, and by the use of pegs and wedges any machine can be pinned down in a few moments at any part of the bench, precisely as work is fastened to the bed of the ordinary planer.

The motors are all supplied with field-rheostats for speed regulation, while the pressure delivered to each motor may be varied either by using a different number of storage cells to furnish the current or by suitable controlling rheostats in each supply circuit. The rheostats for this purpose were recently especially made by the Cutter company, of Philadelphia, and have proved very satisfactory in operation. The motors and dynamos are so arranged that they can be coupled together, mechanically, by direct clutches, or by belts, a very large number of specially prepared endless belts being provided for the latter use. It will be noted from the list above that the direct-current dynamos include machines of the open and closed coil constant-current type, constant-potential machines of both the simple shunt and compound type, and all of bipolar and multipolar varieties, and that they represent the standard practice of American, English, and Canadian manufacturers. To each group of students to whom a special piece of work in the laboratory is assigned, there is supplied a motor, and, if necessary, a separate source of supply, with means of controlling and accurately measuring the speed of the motor and dynamo, means of absorbing the power generated in the dynamo (consisting either of wire or water rheostats), and a special portable testing table and leads to facilitate the work. In this way each group of students is independent and can in no way interfere with the work of another group.

As will be seen from the illustration, there runs overhead, in this laboratory, a two-ton hand traveling crane by which any machine may be picked up and moved to any place on the benches, or taken out of the room altogether, if desired. This is a salient feature of the laboratory; flexibility has been constantly sought, and care has been taken at all times in designing the equipment to fix nothing in place, and to make everything movable to such a degree that it will be possible to move out all the apparatus in a few hours, if this be desired.

In planning the laboratory effort was made to equip it with machines for furnishing different kinds of currents under different conditions, rather than with machines illustrating the particular tendency of dynamo design at the present time. Relations with manufacturing companies have always been such that new types of special interest can, in general, be obtained upon most reasonable terms when they appear of special interest. In this way it is hoped to avoid a large future collection of antiquated types of electrical apparatus. Similarly, through the kindly cooperation of the Canadian telephone interests and the Canadian Pacific Railway Telegraph Company, opportunities for telephone and telegraph work are afforded.

Among the most particular quantities to be measured in any laboratory of this class is speed. While students of the lower grades are given comparatively simple and rough speed-measuring apparatus, the work of those of the upper grades is conducted with apparatus of high perfection. Two methods have been found, by experience in the laboratory, to be simple and very accurate. One of them consists in the use of a small magneto-generator and voltmeter, while the other is a method employing a contact-maker, a condenser,



THE LABORATORY FOR SPECIAL ELECTRICAL INVESTIGATIONS, MCGILL UNIVERSITY.

and a voltmeter. The magneto machines, which were designed by Professor Owens, and built by the Weston Electrical Instrument Company, are instruments of extreme beauty and precision. They absorb a maximum of two and one-half watts of energy for their operation, and consist of the standard magnet of the Weston voltmeter armature with its winding so proportioned that an exactly straight line relation is obtained between its speed and the voltage it delivers. The voltmeter by which the tension of the generator is read may easily be placed at considerable distance away from the running machinery, or where desired, and great accuracy is obtained through the use of these instruments.

For motor testing two types of load are provided, one being a dynamo, whose current is absorbed in a resistance, and the other disk fans. Professor Owens uses, among other types, a highly ingenious special form of transmission dynamometer, and it is stated that it has proved very accurate and convenient in practice. The machine consists of a spiral spring dynamometer, in which the angle of twist of the spring is read directly from a millivoltmeter connected in shunt between terminals, on the fixed and moving parts of the machine, which rest upon a resistance wire, the length of which varies with the amount of torsion on the spring. With a known current the indications of the voltmeter become immediately readable as energy transmitted, and the machine is exquisitely sensitive to the most minute changes of load, while highly accurate in its indications.

Reference to the plan view of the dynamo laboratory will show the distributing switchboard, which is also illustrated in the background of the engraving showing the alternating-current laboratory. This board is so arranged that any source of supply that is available can quickly and conveniently be connected to any supply circuit, or so that any supply circuits and traversing circuits may be connected together so as to allow practically any combination whatever of current and machines to be made. Each of its 12 panels, connected with the different source of supply through a two-pole switch at the top, is provided with a number of bayonet catch sockets, into which flexible conductors can be placed for the connection of its circuit with any of the 10 sources of supply available.

ALTERNATING-CURRENT DYNAMO LABORATORY.

The same general arrangements that obtain in the direct-current laboratory are carried out in the alternating-current dynamo laboratory, the two, indeed, being on the two sides of a row of pillars in the large room shown in the plan as the dynamo laboratory. In this department the dynamos are operated also by individual motors, and each motor is provided with a differential winding, with means of varying the number of effective turns in order to hold its speed constant under wide variations of load. The principal alternating-current machines consist of single two and three-phase machines of the revolving field type, with different shaped pole-shoes to obtain different wave forms, and inductor machines of all phase relations with different inductors for the same purpose. There is, in addition, a Mordey machine with armature coils arranged to be set at any angle, thus furnishing electro-motive forces at any desired definite phase relations with one another. Single and polyphase induction motors, frequency changers, reactive coils, condensers, transformers, synchronous converters and other such apparatus, complete the equipment of this laboratory.

The dynamos listed below afford means of obtaining practically any wave form, and, by connection with suitable transformers, practically any current or pressure that it is necessary to use in the laboratory work. The alternating-current laboratory is supplied with the following apparatus:

One 15-kilowatt, 220-volt, 1, 2 and 3-phase alternating-current generator, revolving field type, Canadian General Electric Company; driven by a 40-horse-power, direct-current, multipolar, variable speed motor, Canadian General Electric Company.

One 15-kilowatt, 220-volt, 2-phase alternator, inductor type, S. K. C. system, Royal Electric Company; driven by a 25-horse-power, direct-current, multipolar, variable speed motor, Crocker-Wheeler Company.

One 15-kilowatt, 100-1,000-volt, single-phase alternator, inductor type, Warren Electric Manufacturing Company; driven by a 20-horse-power, direct-current, multipolar, variable speed motor, Crocker-Wheeler Company.

One 12-kilowatt, 100-1,000-volt, single-phase alternator, Brush Electric Engineering Company; driven by a 15-horse-power, direct-current, multipolar, variable speed motor.

One 20-kilowatt, 1, 2 and 3-phase double ended rotary converter, Westinghouse Electric and Manufacturing Company.

Two 10-kilowatt, 1, 2 and 3-phase rotary converters, Westinghouse Electric and Manufacturing Company

One 2-horse-power, alternating-current, motive-power motor, S. K. C. system, Royal Electric Company.

One 5-horse-power, alternating-current, multipolar, single-phase motor, Wagner Electric Manufacturing Company.

One 3-horse-power, alternating-current, multipolar, induction motor, Westinghouse Electric and Manufacturing Company.

One 10-horse-power, alternating-current, multipolar, 2 and 3-phase induction motor, arranged as a frequency changer, Canadian General Electric Company; driven by a 10-horse-power, direct-current, multipolar, variable speed motor, Crocker-Wheeler Electric Company.

To vary and regulate the speed of motors, field and armature rheostats, made by the Cutter Company, Philadelphia, are provided.

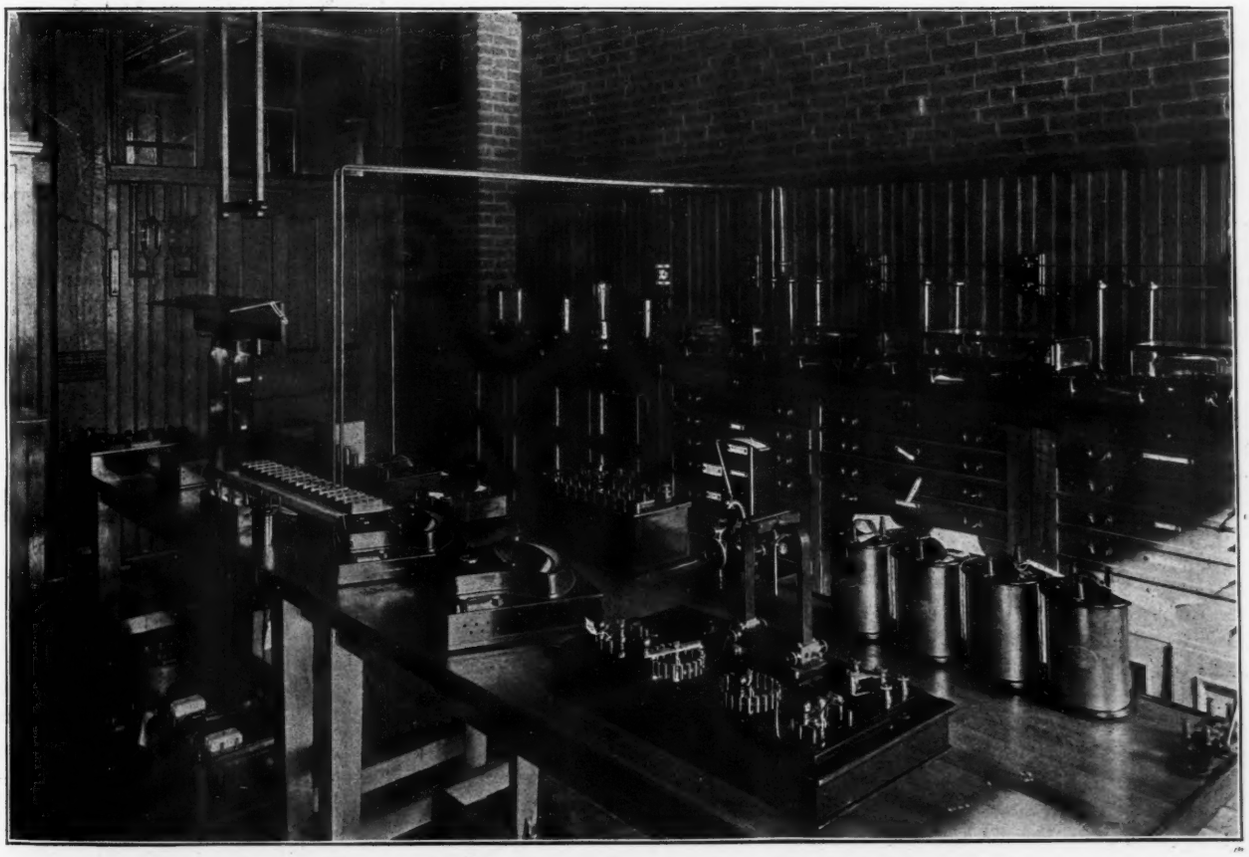
For electro-motive-force wave-determinations, Mershon's method is generally used, but for current wave determinations, when it is important to reduce the resistance and inductance introduced in the measuring circuit to a minimum, as, for example, in the study of current waves in the winding of the rotor of an induction motor, a modification of Duncan's method, introduced by Professor Owens, has been found valuable, while it is certainly highly ingenious and interesting. A small suspended coil carrying a mirror is connected through a contact-maker with a definite source of direct current. This coil turns in a magnetic field produced by two windings arranged on the same axis, one of which is of only one or two turns, and of low resistance, and carries the current to be measured; while the other is connected also to a source of known direct current and through a resistance and amperemeter, so that the current flow in it may be regulated as desired. It is evident that with this arrangement the strength of the field in the latter coils may be such as to compensate exactly for that produced in the coil in the main circuit at the instant that the contact-maker is connected. The instrument then becomes a zero instrument, and it is found in practice that it can be worked very rapidly and its indications may be made very reliable.

Some of the work recently done in this laboratory consists of a study of the conditions affecting successful parallel operation of synchronous converters; the relation of electro-motive force wave-forms to load and power-factor of load in alternators under different conditions; the effect of wave-form on the operation of induction motors; a study of frequency changes; a study of electrical speed and frequency indicators, etc.

THE LABORATORY FOR SPECIAL INVESTIGATIONS.

This laboratory is supplied with direct and alternating currents of all sorts, and

THE HIGH-TENSION LABORATORY, MCGILL UNIVERSITY.



THE LABORATORY FOR STANDARDIZING ELECTRICAL INSTRUMENTS, MCGILL UNIVERSITY.

contains a number of tables conveniently arranged and wired. Meter and transformer testing is done in it, while of late considerable work has been done in the testing and study of constant-current transformers. The research laboratory is provided with a large assortment of special instruments, a list of which would occupy too much space here.

THE HIGH-TENSION LABORATORY.

This room has been fitted up for the study of alternating current of very high pressure. Its equipment consists of four 10-kilowatt, 50,000-volt transformers, and one 20-kilowatt insulating transformer, all made by the Westinghouse Electric and Manufacturing Company. It is supplied, as the illustration clearly indicates, with a switchboard, regulator heads, impedance coils, a Stillwell regulator, and a Kelvin electrostatic voltmeter reading from 15,000 to 150,000 volts. This instrument is shown in the middle of the floor in the illustration. Among various investigations now under way in this laboratory are studies of the effect of prolonged electrostatic stress upon the breakdown strength of insulating materials; the effect of temperature on the breakdown strength of various solid dielectrics; the conduction of currents in air between electrodes of different forms, and the effect of wave-form upon striking distance in air under various conditions.

THE STANDARDIZING LABORATORY.

One of the most interesting features of the whole laboratory equipment of McGill is the standardizing laboratory, of which a fair idea may be had from one of the accompanying illustrations. The room is equipped with current supply, both direct and alternating, up to 1,500 or 2,000 amperes. Along the shelf at one side is mounted a series of Kelvin balances, four in number, reading among them from zero up to 600 amperes. The room is also furnished with Weston laboratory standard direct-current instruments, Elliott and other potentiometers, standard resistances, galvanometers, etc., and is so arranged that the calibration curves of any instrument having a current range up to 1,500 amperes, and a pressure range up to 3,000 volts, can be obtained in a very few minutes. All of the instruments, balances, standards, etc., can immediately be checked against standard cells, whose electro-motive force is known, or can readily be determined by the use of a silver voltameter. An instrument which has given excellent results is a potentiometer made upon Crompton's design of the bifilar d'Arsonval type. Kelvin's standard multicellular voltmeters, similar to those used by the Board of Trade, in London, are provided for alternating-current voltmeter calibration. For the calibration of alternating-current instruments, such as wattmeters and voltmeters, by direct current, without the labor required in the method of reversals, soft iron shields of such size and shape as practically to exclude the earth's and other stray magnetic fields are employed. Among other instruments in this laboratory are Ewing's permeability bridge and hysteresis meter; Thomson's high-resistance galvanometers; and numerous standard cells, resistances, phase shifters, condensers, potentiometers and other instruments of this class. The whole design of the laboratory is based upon the necessity for rapid work on account of the fact that 150 to 200 instruments must continually be checked against standards and kept in calibration, while much standardizing is done here also for manufacturing and other concerns in Canada.

Among the other features of the instrumental equipment of this laboratory may be mentioned the following list of apparatus:

Two Stanley hot-wire ammeters; 2 Siemens electro-dynamometers; 20 Thomson ammeters, voltmeters and wattmeters; 10 Nalder ammeters and voltmeters; 60 Weston ammeters, voltmeters and wattmeters; 2 Cardew voltmeters; 6 recording wattmeters, various types; 25 ammeters, voltmeters and wattmeters, miscellaneous types; 4 magneto generators, with special multivoltmeters (used as speed indicators), Weston Electrical Instrument Company; 6 revolution counters; 2 mechanical speed indicators; contact-makers for each alternating-current machine; 6 current transformers; 3 sets of 64 11-plate, type E chloride accumulators, 25-kilowatt-hour capacity, eight-hour discharge rating, the Electric Storage Battery Company; 100 three-plate, type B chloride accumulators, for voltmeter calibration, the Electric Storage Battery Company; 1 four-panel battery switchboard, equipped with instruments, circuit-breakers, etc.; 1 six-panel distributing switchboard, alternating-current and direct-current dynamo laboratories; 1 main-panel switchboard, with instruments and circuit-breaker, dynamo laboratory; 25 arc lamps, with switchboard; 1 five-kilowatt, 110-40-volt, direct-current motor generator, for charging accumulators, the Crocker-Wheeler company; 7 commercial condensers, adjustable capacity, the Royal Electric Company; a great variety of transformers and potential regulators; 7 absorption dynamometers, for motor testing; 1 transmission dynamometer for motor testing; specially designed tables, wired and equipped with switches, circuit-breakers, etc., for each pair of machines (motor and dynamo) to facilitate experimental work.

It is hard to overestimate the usefulness of an institution provided with so magnificent an equipment for instruction and for the carrying on of that variety of research work which leads to new and important results. As greatly as McGill University is to be congratulated upon the splendid liberality which has given it so fine an equipment, and upon the intelligent direction under which its resources are being used, the Dominion of Canada is still more to be congratulated upon having within its limits an institution capable of producing so many and various good results, and aiding in so direct a way the development of that country and its unparalleled natural resources.

A Shocking Occurrence.

During a recent storm in Pittsburgh, Pa., the office of the Excelsior Express Company, in the Union Station of the Pennsylvania Railroad, was so electrified that persons touching the walls, metal trunk checks, or attempting to pass money through the window of the office, were severely shocked. In instances where persons having umbrellas with metal rods chanced to touch the walls with them their fingers were severely burned. The phenomena finally assumed such a dangerous aspect that no one was allowed to approach the express office, but in the course of a few hours all indications of the electricity had disappeared. The matter is explained by the fact that the window sill of the express office and the station platform were both soaked with water by the rain which made them good conductors, and the air was so filled with electricity, that combined with leakage supposed to have come from the light wires, the shocks were pronounced.

Pacific Cable Bid.

A cable despatch from Sydney, N.S.W., states that a bid has been made by a telegraph construction company for the laying of a Pacific cable at a net cost of £17,950,000. The bidder guarantees the completion of the work by July 1, 1902.

The Dayton & Maysville, Ohio, Electric Railroad Company has elected Mr. Eberly Smith, president, and F. M. Conden, secretary and treasurer. The stockholders have amended the charter so as to change the name to the Cincinnati, Dayton & Maysville Electric Railway, and to extend the road into Cincinnati.

THE PLANT OF THE ST. CROIX POWER COMPANY, OF WISCONSIN—II.

BY HENRY FLOY.

TWENTY-FIVE THOUSAND VOLT OVERHEAD AND UNDERGROUND TRANSMISSION LINE.

Two three-wire, three-phase transmission circuits, each consisting of 24½ miles of overhead bare copper wires and three miles of underground cables connect the generating plant with the distributing station in St. Paul.

Both overhead circuits are carried on a single line of poles. The wires of each circuit are on one side of the poles and are supported so as to be at the verticals of an equilateral triangle, having 24-inch sides. The conductors are of No. 2, B. and S. medium hard-drawn copper wire carried on glass insulators of the "Provo type"—the same as those used on the 40,000-volt transmission in Utah. The insulators are seven inches in diameter and have a triple petticoat. They are mounted on special locust pins, boiled in paraffine, carried on two four-inch by five-inch Oregon fir cross-arms. The poles are mainly of Oregon fir and are spaced not more than 110 feet apart. No poles less than 30 feet in length and eight inches in diameter at the top are used. Poles of minimum length are planted five and one-half feet in the ground and six inches deeper for every additional five feet in their length. The line was designed to be practically level, irrespective of irregularities in the earth's surface. The corners and angles in the line are reduced to as few as possible, consistent with securing a right-of-way at a reasonable price; no angle in a conductor at any insulator is less than 165 degrees, thus avoiding any dangerous tendency to break the pins. In making a right angle turn special construction is used (see Fig. 9), affording seven points of support for each wire. For slight turns two or three poles, as may be required, are set 10 feet apart but no more than one insulator per wire is allowed on a single pole.

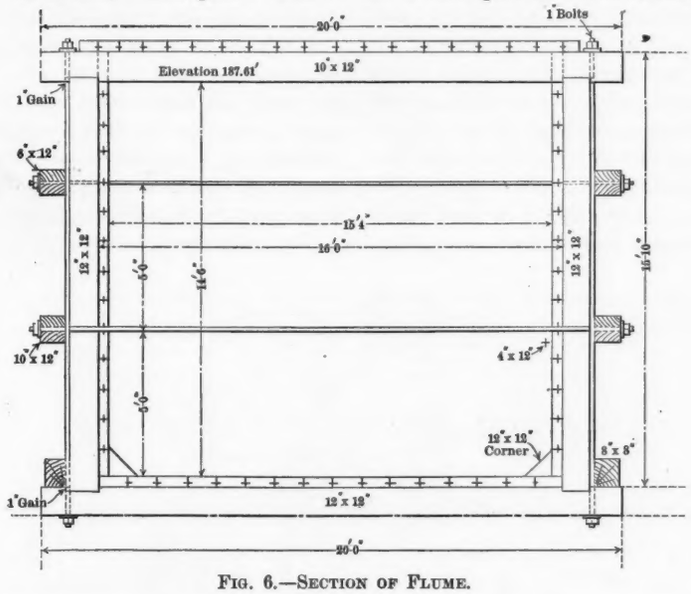


FIG. 6.—SECTION OF FLUME.

The transmission line really takes its beginning at the terminals of the step-up transformers in the dynamo-room of the generating station, whence it passes through the Westinghouse high-tension switches into a brick lightning arrester house abutting against the end of the power-house. Here are located choke coils and lightning arresters. From the arrester house the wires pass out through circular openings in the wall which are sheltered by a gabled roof and run thence in a general western direction to a similar arrester house in the city of St. Paul, where they terminate in the heads of the underground cables.

No especial engineering difficulties were met with in the construction of the aerial line, except in crossing the St. Croix river which is about a half mile wide, with precipitous banks 100 or more feet in height. Advantage was taken of a bridge built by the Wisconsin Central Railway, and long oak pieces were fitted between the ties every 50 feet throughout the length of the bridge. These oak pieces project about 20 feet beyond the edge of the bridge and on them the six wires are carried in a horizontal plane. To nullify any bad effects of the ironwork in the bridge, the wires of each circuit are spiraled three times in the length of the bridge.

As is usual with two parallel three-phase circuits, one circuit is spiraled twice relatively to the other circuit, in addition to the transpositions on the bridge, to prevent mutual induction.

Six feet below the power transmission circuit on a separate cross-arm are carried two No. 10 galvanized iron wires, which constitute the telephone line. The wires are transposed at every fifth pole, which very satisfactorily avoids any inductive effects in the line and results in very efficient telephone service.

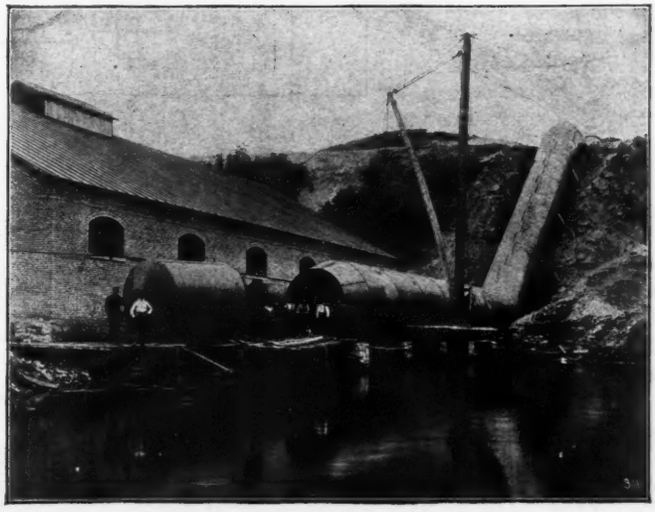


FIG. 7.—12-FOOT STEEL PENSTOCK.

There are two three-conductor lead covered cables connecting the lightning arrester house with the distributing substation located on Cedar street in the very centre of the business section of St. Paul. These cables are in four-hole McRoy vitrified clay conduits laid in concrete. The

conduits follow the grade of the streets except where it was necessary to pass under a number of railroad tracks in a deep cut. Here, the conduits end in the top of a brick well about 50 feet in depth, down which the cables drop, passing from the bottom of the well in other conduits to another well on the opposite side of the tracks through which they rise again to the conduits laid below the pavements of the street.

In considering the use of cables for 25,000-volt transmission under ground, the writer found that a number of reputable manufacturers not only declined to bid on his specifications, but would not entertain any proposition for furnishing such cables, even under their own specifications. There were only two companies that would undertake the work and accordingly a contract was entered into with these companies, one to furnish a rubber insulated and the other a paper insulated cable.

The specifications provided that the general design of both cables should be the same, that is, each conductor having an area not less than 66,000 centimetres, is composed of seven strands of copper wire, enclosed in insulation, the three laid up in jute and the whole enclosed in a jacket of the same insulating material as that used about each conductor. Outside of the jacket is the lead sheathing one-eighth inch in thickness, making the cable complete about two and one-fourth inches in diameter.

The "National" cable is insulated with paper treated with a secret compound. The insulation about each conductor is nine-thirty-seconds of an inch in thickness. That of the enveloping jacket, four-thirty-seconds of an inch thick. The covering of this cable is of lead protected on the exterior by a coating of tin.

The insulation of the "Safety" cable is about a 35 per cent compound of the best "old up river" Para rubber seven-thirty-seconds of an inch thick around each conductor, wrapped with a drilled tape served with jute, with the jacket five-thirty-seconds of an inch thick. The sheathing of this cable is of lead mixed with three per cent of tin.

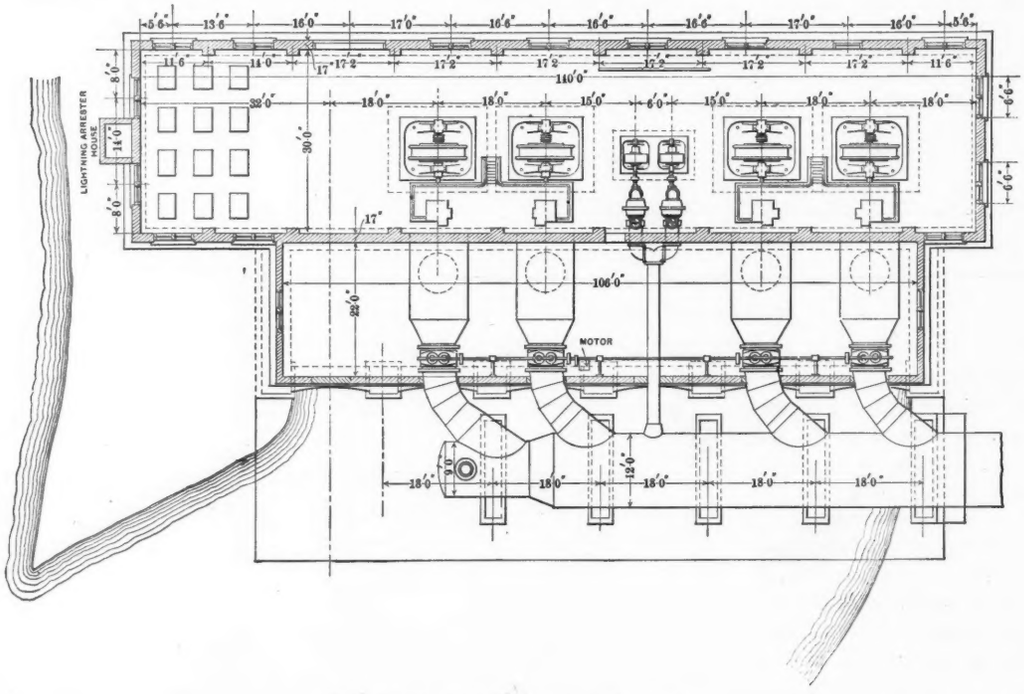


FIG. 8.—PLAN OF GENERATING STATION.

The contracts entered into with the above companies for cables included not only their manufacturing the cables and testing them to 40,000 volts in their factories before shipment, but also the installation of the cables complete ready for operation in the conduits in St. Paul. The contracts further include a guarantee for a period of five years protecting the purchaser against any breakdown in the cables, except those due to extraneous and mechanical injuries, and further permitting at any time during that period, the testing of the cables *in situ*, up to a potential of 30,000 volts. The writer's aim in having the contract for each cable awarded to a separate company was to secure the benefits of competition, in promptness of delivery and perfection of manufacture. Furthermore, as underground work of such tension had never been attempted before, there was some question as to whether rubber or paper would prove the more durable insulator under these conditions.

While of course the ultimate success of 25,000-volt underground transmission can only be determined by the lapse of time, and the action of high voltage in its effect on the insulation, nevertheless the success in operating seems to have demonstrated the wisdom of the experiment and great credit must be given to the companies for their co-operation in undertaking what had never before been attempted and what many manufacturers prophesied would result in failure.

The calculated resistance of each conductor between the generating and distributing station is 23 ohms. The drop in voltage between the same points, for 3,000 kilowatts delivered with a 90 per cent power factor, and 25,000 volts initial potential figures 7.7 per cent operating both lines in multiple, which will be the usual practice.

SUB-STATION AND APPARATUS.

The distributing station in St. Paul is an iron and brick building designed to contain the necessary apparatus for reducing the potential and controlling and transforming the energy received over the transmission line, for distribution in the city of St. Paul. The building is 50 feet by 70 feet, two and a half stories in height. One-half of the building has a basement divided into two rooms, one, in which all the static step-down transformers and

high-tension switches are located, is connected by a tunnel with the street conduits; the other serves as a toilet room and place in which to locate the apparatus for heating the station (see Fig. 10). The main floor is divided into three rooms, open to the roof. The larger room, 50 feet by 50 feet, contains six 250-kilowatt rotary converters and two marble switchboards, extending along two sides of the room. The second room on this floor serves as a hallway to the main room, and affords a place in which to locate telephone box, etc. The third room is open from the roof to the basement but is entirely cut off and separated from all the rest of the building, except for a single door from the hallway. This room is intended for a storage battery, which it is planned to install later.

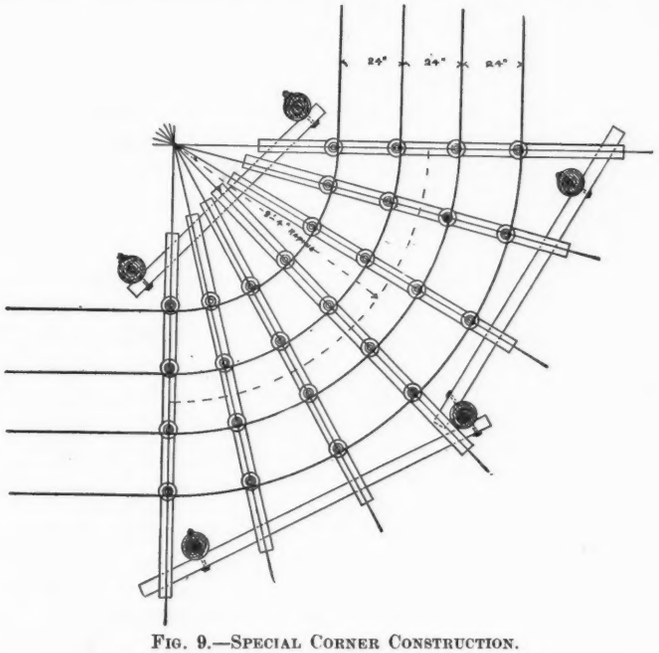


FIG. 9.—SPECIAL CORNER CONSTRUCTION.

Each conductor of two high-tension cables passing through the tunnel into the transformer room, ends in one terminal of a single-pole knife switch, to be operated only when current is off the line and installed to permit convenient testing of cables, etc. The other terminal of each switch is connected to a high-tension bus-bar, from which taps are taken off to the high-tension switches controlling the circuits to the different sets of transformers. The ends of the cables are also connected to static discharges, which are merely a number of standard lightning arresters, connected in series.

The high-tension bus-bars and their taps to the high-tension switches and from the switches to the transformers, are single conductors insulated with one-fourth inch of best Para compound, and guaranteed to withstand 25,000 volts continuously. The conductors are carried in conduits made of wood pulp indurated with asphaltum, manufactured by the Fibre Conduit Company. The conduits are guaranteed to withstand 20,000 volts without breaking down.

The high-tension oil switches are of the single-pole three-break type, operating under oil and designed to break 25,000 volts and 50 amperes. The switches are closed by hand but opened by the releasing of a latch controlled by a local circuit from the main switchboard upstairs. There are 24 high-tension switches in all—12 connected with each set of the cable bus-bars. As all high-tension work is three-phase, this necessitates the closing of three switches to connect any set of transformers with either set of bus-bars (see diagram connections Fig. 11).

There are four banks of static step-down transformers—two banks consisting of three 22,500 to 78-volt oil-cooled 300-kilowatt three-phase to six-phase transformers and two banks of two 22,500 to 2,100-2,700-volt oil-cooled 200-kilowatt three-phase to two-phase transformers.

Each one of the 300-kilowatt transformers has a single winding on the primary, and two entirely distinct and separate windings on the secondary. By connecting three of these transformers in a set, the three-phase to six-phase, transformation is affected. One set of these transformers supplies current to the rotary converters, operating between the positive and neutral wires, and the other set to those rotaries operating between the neutral and negative wires of the Edison three-wire system of distribution throughout the city. There is kept on hand a spare transformer in case of break-down, but as all transformers in the sub-station are connected in delta, it is perfectly feasible to successfully operate, although there are but two transformers of a set connected in circuit. In fact, this was the method of operating for the first few weeks after starting the plant and until the remainder of the transformers were received.

The two identical sets of three-phase to two-phase 200-kilowatt transformers provide for the alternating-current distribution throughout the city. On the front of each transformer case is mounted a quick-break multipoint switch connected with leads brought out from the secondary windings of the transformers. The movement of the switch throws more or less turns of the secondary in circuit and thus adjusts the potential in steps of 21 volts to any desired point between 2,100 and 2,700 volts.

The plan of operating from the generating station is to maintain irrespective of load or line loss, the potential on the high-tension bus-bars in the sub-station at 22,500 volts, as shown by the potential indicators previously described. This potential gives 78 volts for the rotary converters which potential may be varied seven volts either up or down, by use of inductor regulators of which there is one for each rotary. In a similar manner the potential for alternating-current distribution is regulated by the setting of the multipoint switches at any point between 2,100 and 2,700 volts, depending on the load.

PERSONAL.

Professor R. B. Owens, of McGill University, Montreal, was in New York last week, in attendance at the meeting of the American Society of Mechanical Engineers.

Mr. J. M. Atkinson, the well-known electric railway supply dealer, of Chicago, accompanied by Mrs. Atkinson, arrived in New York city last week from Genoa, Italy. Mr. and Mrs. Atkinson have been enjoying a vacation of several weeks' duration in foreign parts.

Mr. E. H. Abadie, of the Wagner Electric Manufacturing Company, St. Louis, was a New York visitor last week. Mr. Abadie has been in the East and Northeast for several weeks past, and reports business very active, and the outlook for 1901 for electrical manufacturing in general as very promising.

Mr. James Parmelee has been selected as president of the National Carbon Company, of Cleveland, to succeed Mr. Lawrence, recently deceased. Colonel Myron T. Herrick succeeds Mr. Parmelee as vice-president. The vacancy in the board of directors, caused by Mr. Lawrence's death, has not yet been filled.

INDEPENDENT TELEPHONE EXCHANGE OWNERSHIP AS AN INVESTMENT.

BY BURT HUBBELL.

In considering an industrial investment the points of importance to take notice of are:

1. The demand for the product to be produced, or manufactured, or sold, and the permanency of the demand.
2. Present and future competition.
3. Profit on the commodity to competitors.
4. Ability to produce or manufacture as good or better quality, and as cheap or cheaper than competitors, and to market goods as economically.
5. Ability to realize promptly on sales.

Let us take these questions in the order in which they are named, and apply them to an investment in telephone exchanges working in opposition to the Bell telephone interests.

In answer to the first proposition, until the past year or two the telephone has been sparingly used, owing largely to the refusal of the Bell Telephone Company to make reasonable rates of charges for its services, and has been considered more as a luxury than as a necessity. Up-to-date business houses have not heretofore helped the demand for more than one telephone in their offices, being content to use it to its capacity and let the overflow of calls wait their turn, whereas now they have several telephone instruments side by side so as to catch every possible customer.

Residences, good ones, have plodded along without these services for the same reason, excessive prices; and many people, well-to-do, have not used the telephone heretofore largely from lack of habit. Now that competition has made it possible for everyone to have a telephone, the masses are being educated to the telephone habit, a habit which, once acquired, will ever grow and one that can never be stopped. In the near future residences of sufficient value to demand modern conveniences such as hot and cold water, bath, etc., will require telephone service as much as if not more than other modern household conveniences.

The average number of telephones to population a few years ago was about 15 to 20 to every 1,000 people. To-day it is from 35 to 50 to 1,000 people, and it will soon grow to be more than 100 to 150 to every 1,000 people. The demand for telephone service is so enormous, and the amount of money invested in taking care of this demand is so great as to place this line of trade in the foremost ranks of the world's enterprises.

Telephone exchanges have never been known to reach their limit in numbers of subscribers, as there is always a steady demand for their services that will be an ever increasing one.

Regarding the second proposition, competition, while it is impossible to secure an exclusive franchise or a monopoly for the operation of a telephone exchange yet, in practice, exchanges operating in opposition to the Bell company have practically an exclusive right as to their particular list of subscribers or customers, if the service given is satisfactory and complete and the rates reasonable, and this has been the policy of the Independent telephone interests. The subscribers are going to stand by the opposition company, even though the Bell Telephone Company give service gratis. The public and the company are partners against the high rates of the Bell monopoly, the public benefitting in the agreement by being assured of a uniformly low rate for telephone service as long as the competition is sustained, and the company benefitting in the lack of competion for its subscribers and a further return for its investment. There will be, of course, the competition of the Bell company for new business after the opposition exchange is started, but it is not of that obstinate character that is met with in other lines of trade; for when the subscriber is once secured to the service of the opposition company the competition, to him at least, ceases. The future competition, after the list of subscribers is established, depends absolutely upon the management of the business. If the opposition exchange management will pay close attention to its business, administer it intelligently and economically, and cater to the wants of its customers as other lines of trade are obliged to, there can be no inducement offered to its subscribers to discontinue the use of their services, and it can be assured of an ever increasing business at such rentals as will pay interesting dividends in the investment.

The third proposition, profits of competitors, is easily answered by referring to the enormous profits made by the American Bell Telephone Company and their licensees during the past 20 years, the tremendous amount of watered stock, and the large dividends on it. These profits, of course, have been made from the former high prices charged by this monopoly for its services, but with lower prices and greatly increased business, the profits of these companies should show an even better proportion in the future than in the past. Opposition companies universally operate with larger lists of subscribers than their Bell competitors, and as the profits of the Bell company are not questioned their should be no hesitancy in the mind of a possible investor in this line of work as to the profits to be earned by the opposition company.

Fourth proposition—ability. The opposition or independent telephone business has been, and is at the present time, so good that it has withstood the abuses it has been so often subjected to through the lack of knowledge of its promoters and manufacturers and operators as to the proper construction, the proper material and apparatus to use, and the proper management to give to its maintenance and extensions. It speaks volumes as to the value of the business to know that a butcher, a baker, a candlestick maker, etc., should form a company, as has been the rule up to the present time, build a telephone exchange, operate it against the educated brains of the great Bell monopoly, and beat them almost to a standstill in numbers of subscribers and profits. The credit for this state of things is due, however, not so much to the said butcher, baker, etc., as to the long suffering public who are willing to put up with almost any kind of service in being relieved of the ever tightening grasp of the Bell company.

But give the independent telephone companies the benefit of the trained talent that can be secured to-day in the development of a telephone exchange, and let them follow the high class of specifications in constructing their plants, in the material and apparatus to use, and the manner in which to operate, and they will be able to give a more complete and satisfactory service than their competitors are giving, and will be able to maintain it at a greatly reduced price per telephone. Their apparatus will be newer and more up to date, and with the influence of their home directors (which is a very desirable influence to have in this class of work), a great deal of work can be acomplished without visible cost to the company. The general public is so heartily in favor of this competition that the work of catering to their requirements will be comparatively easy, and the opposition company will be relieved of some of the many expenses of its less fortunate competitor.

The opposition companies have a further very considerable advantage over the Bell company in the fact they are not obliged to pay tribute in the form of rentals for telephone apparatus. This is

a very considerable item, and gives them a very considerable advantage over their Bell competitors. It is therefore safe to say that the independent company can operate its plant at a much less cost per telephone than can the Bell company.

Fifth proposition—ability to realize on sales. If there is one thing above another in this business that appeals to the investor it is the ability to realize on the accounts receivable. To engage in a line of trade where the payments are made before the commodity is delivered certainly makes a very interesting proposition. It is a remarkable fact, yet true, that telephone subscribers will pay their rentals in preference to their grocery bill, and a well managed exchange need have no loss in the matter of collecting its acounts. This condition is largely due to a fear lest the telephone company give publicity to the fact that they have not paid their telephone rental, and the further fact of the telephone habit being such a strong one as to make it impossible to do without this service once having learned to depend upon it.

In summing up the situation we have a line of business that is practically in its infancy, as far as general uses are concerned, and that will show a tremendous demand for its product for all time to come; a business that is practically free from competition, as to its particular line of subscribers, or customers, and a business that has the advantage over its older competitors in newer and more up-to-date-construction of apparatus; a business that has the hearty good wishes and support and interest of the general public, particularly for the reason that the success of the competing telephone company means their success in assuring themselves of reasonable charges for their telephone service; a business whose output is contracted for and sold for a term of years for cash in advance, and whose output is an ever increasing one. Can a more ideal investment be imagined? Starting business with a guaranteed list of subscribers for a term of years, guaranteed to take all the output produced, and pay cash for it before it has been produced; knowing at the first of the year the minimum sales, and knowing further that they will be greatly increased during the year; knowing from the experience of others the cost of maintenance, being relieved of uncertain expenses (such as delivering, etc.) to sell the product—there is but to add, substract, and divide, to know before you start just what the minimum profits of an enterprise of this kind are going to be.

It is as safe a business as any in existence to-day, and is far more profitable than many that are more hazardous.

Telephone and Telegraph

The Erie telephone system made a net gain of 2,107 subscribers in November. Total number connected November 30, 139,321. Number waiting connection, 2,853.

A recent incorporation in Columbus, Ohio, is that of the Norwalk & Huron County Telephone Company, of Norwalk, with a capital of $80,000 subscribed by local interests.

The Republican Ways and Means Committee in considering the reduction of $30,000,000 of revenue in the war tax act has practically determined to abolish the stamp on telegrams.

The number of subscribers of the Galveston, Tex., telephone exchange at the time of the recent cyclone was 2,000. Since the disaster 400 subscribers have been received and the number is growing at the rate of 50 per day.

At a recent meeting of the stockholders of the City and Suburban Telegraph Association, of Cincinnati, Ohio, the proposed addition of $1,500,000 to its capital stock was voted. Out of the 49,000 shares representing the stock, 47,830 were voted.

It is stated that the Wisconsin branch of the Erie Telephone Company increased its capital stock about $2,000,000 on November 26, thus bringing figures up to $15,000,000. Half of the additional capital will be immediately put into improvements in Milwaukee and throughout the state.

A new telephone company is now being promoted in Norfolk, Va., and will be known as the People's Telephone Company. Its capital stock will amount to $200,000, and each subscriber, in addition to receiving a low rate for telephones, will be permitted to purchase stock. Long-distance connection will be had.

A contract between the Maryland Telephone Company, of Baltimore, and the Cayuga Telephone Company, of Cleveland, Ohio, has been closed for long-distance service throughout a considerable part of the West. The former company intending to build lines to connect Baltimore with Pittsburgh, through which city the new service will become available.

Some years ago when the Edison telephone was first introduced into England, Mr. E. H. Johnson, who promoted the industry there, is reported to have said that when he offered the telephone to London merchants he was scoffed at. He says that going to the head of a large London company and explaining the value of the instrument, that gentleman answered: "We have been doing business here for 400 years and we never had a telephone. I think I can get along without them."

The Erie Telegraph and Telephone Company will hereafter have its main office in New York city, having removed from Lowell, Mass., last week. Charles J. Glidden, president; H. J. Pettengill, vice-president; George B. Perham, secretary and auditor, and T. W. Greenslitt, manager advertising department, with their immediate staffs, will make their headquarters in New York city. The Boston office will be under the management of Vice-President Charles E. Adams and Treasurer Charles A. Grant, and their immediate staffs.

In a recent statement to a newspaper, President Glidden, of the Erie, estimates that the present status of the telephone industry in this country has reached only about 25 per cent of its possible and probable extent. Mr. Glidden's estimate is based upon the fact that development in California has reached 75 per cent, San Francisco with 342,000 population having 20,600 subscribers, and Los Angeles with 102,000 population having 78,000, those being the highest percentages in the country. This year the Erie system will spend at least $7,000,000 in developments, $2,000,000 of which will go for long-distance lines. It is estimated that the system will gain about 240,000 subscribers this year. Its total of capital invested is estimated at $50,000,000, of which $38,000,000 represents switchboards, $10,000,000 long-distance lines and $2,000,000 real estate.

Of the 15 fire stations in Berlin, Germany, which have underground circuits to the fire-alarm boxes, a specially made telephone has been added, permitting instant communication between the nearest station and any alarm box during the progress of a fire. A microphone, fitted with battery, switch and second receiver, is suspended from a frame attached to the Morse apparatus at the station. An induction coil, a condenser and a circuit key complete the instrument, and instead of having a telephone at each alarm box, a portable set is used which is attached to the fire-alarm post or box with a plug or socket. Each of the 80 fire carts carries these portable sets and the bicycle brigade uses a somewhat smaller set of more compact design. Simultaneous telegraphing and telephoning over the line does not spoil the effect of the instrument, although a considerable vibration or ticking effect is heard.

The Independent Telephone Exchange at East Liberty, Pa.

The independent telephone exchange at East Liberty, Pa., is one of a number of branch exchanges that the Pittsburgh & Allegheny Telephone Company, of Pittsburgh, has recently added to its system, the whole being an excellent example of recent independent telephone construction in this country. The East Liberty exchange is one of the two largest branches, having a present equipment of 800 subscribers' lines, with provision for a future extension to 3,000.

The exchange is located in a modern two-story building, of pressed brick with stone trimmings, which was built especially to meet the requirements of a telephone exchange. The operating room is on the second floor, while the power-plant, storage batteries, long-distance department and general offices are on the floor below. The building is well ventilated, has light on three sides and is heated by a steam plant in the basement.

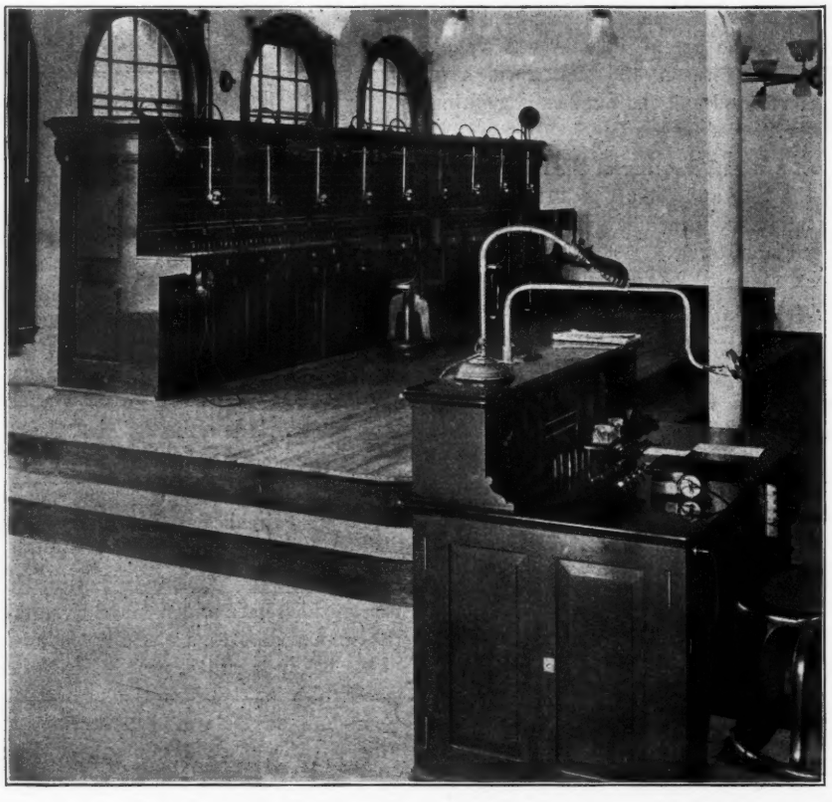


FIG. 1.—VIEW OF OPERATING ROOM IN EAST LIBERTY, PA., TELEPHONE EXCHANGE

The switchboard is designed to operate on the central-battery plan and has all the latest features in the way of automatic calling and supervisory signals. The switchboard and all central-office apparatus were furnished by the Kellogg Switchboard and Supply Company, of Chicago.

A view of the main board is shown in Fig. 1. It consists of three sections of a six-panel multiple switchboard, having three operators' positions per section. Two sections and two positions are equipped for local and outgoing trunk work, and one position for incoming trunk work. All three sections are equipped with a multiple of 800 lines. Each section has a capacity of 360 lines and at present is equipped with 300 answering jacks and drops, so that during the busiest portion of the day each operator answers the calls of 100 subscribers.

Trunking with other exchanges is carried on by means of 60 outgoing and 60 incoming trunk lines. Incoming trunk lines terminate in jacks at the first operator's position, which also contains the full number of multiple jacks so that the operator can complete any connection called for. The 60 outgoing trunk lines are multiplied through all three sections so that any incoming call can be transferred directly to any other branch exchange.

The framework of the switchboard is of structural iron, firmly rivetted and bolted together. The woodwork is seasoned mahogany, the key-shelf being made five-ply to prevent warping. The legs of the switchboard are 43 inches high and rest on the true floor of the exchange. A false floor 17 inches high is placed above this, which makes the height of the key-shelf above the false floor 26 inches. To the back of the legs is fastened the connecting rack to which all wiring from the answering jacks, drops, key-shelves, operators' circuits, etc., is brought.

The jacks and drops are mounted on pins projecting from the rear of the stile strips and each is held in place by a hexagonal nut at each end. The black ebonized finishing stiles, which cover the stile strips and designate the numbers of the jacks, together with the ebonized blanks that fill the blank panels, give the board a black finish, which is only relieved by the white holly strips. These are one-eighth inch in thickness and support the jacks in banks of 100. All jacks are mounted on half-inch centres, vertically and horizon-

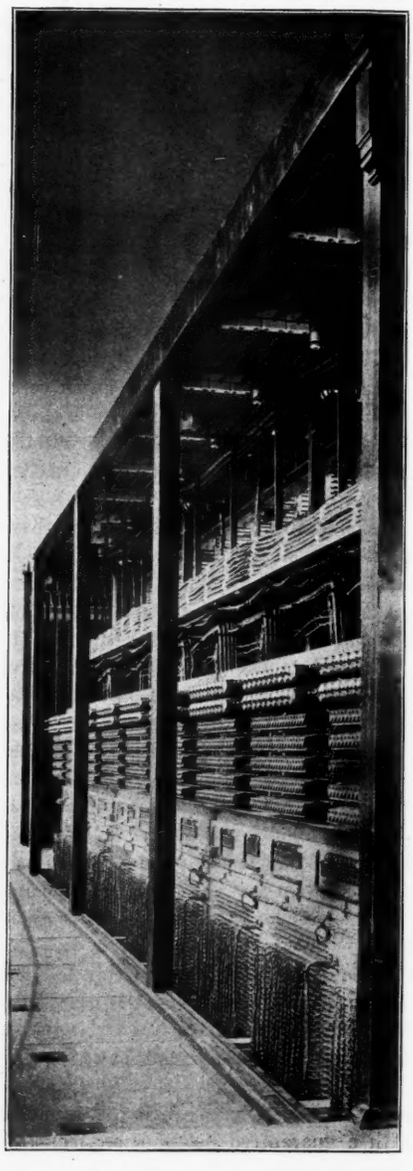


FIG. 2.—REAR VIEW OF SWITCHBOARD—SHOWING MULTIPLE CABLING AND RELAY RACKS.

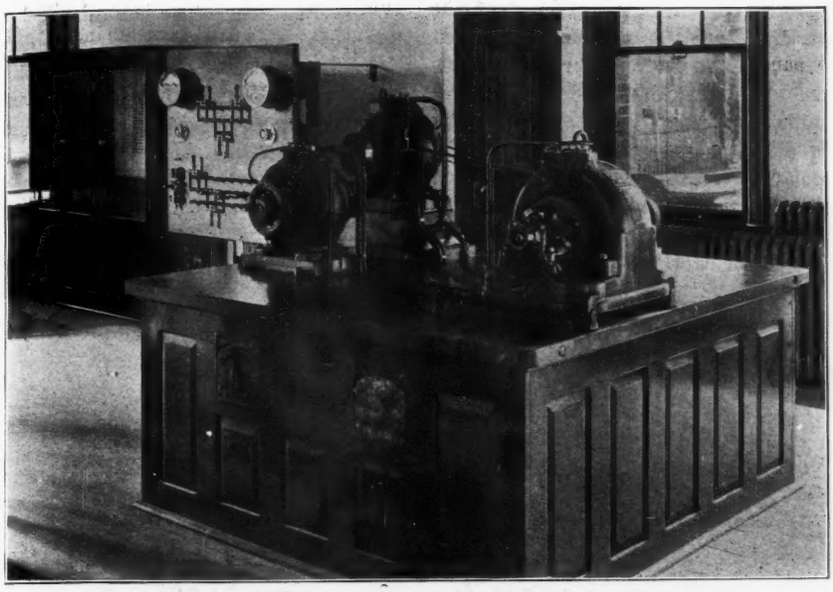


FIG. 3.—POWER PLANT OF THE EAST LIBERTY TELEPHONE EXCHANGE.

tally, and the answering jacks correspond exactly with the drops, which are also placed on half-inch centres, horizontally. The drops are arranged in strips of 20 immediately above the plug shelf and the answering and multiple jacks are immediately above. The row of jacks between the answering and multiple jacks is for outgoing trunk lines.

A rear view of the switchboard is seen in Fig. 2. At the bottom is shown the connecting rack, while immediately above are the power wires and fuses. The line cut-off relays are shown in banks of 20 and also the supervisory relays arranged 10 to the strip. Above these is visible the wiring of the answering jacks and the multiple cabling. All multiple cables are of 21 twisted pairs of tinned copper wire, having an inner insulation of silk and one of cotton, colored in accordance with a code, to aid in the proper selection of wires. A double wrapping of paper is then put on, and an outside braid of cotton, the whole being saturated with beeswax. All multiple cables are formed and soldered to the jacks before leaving the factory, and are ready to be laid in place after the board has been set upon the floor.

The operation of answering a call and making a connection is as follows: The act of taking the receiver from the hook automatically sends current over one side of the line and gives a positive signal to the operator. She then inserts the answering plug into the answering jack in the usual manner. This serves to operate the line cut-off relay, which disconnects the line from the line signal and connects it with the proper jack at the same time throwing the line side of a battery on the test rings of that line. After ascertaining the number desired, the calling plug of the cord circuit is then inserted in the jack corresponding to the number and by means of a ringing key, a pulsating current is sent through the ringer of the party called. Connected with the calling plug is a supervisory lamp, operated by a supervisory relay, which lights up upon the insertion of the calling plug into the jack and remains lighted until the subscriber called takes his receiver off the hook. This notifies the operator that the call has been answered. A corresponding lamp and relay are connected with the answering plug. During conversation the lamps are both out, but when either party hangs up his receiver, the corresponding lamp lights, and when both are lighted, the operator knows that the line is no longer in use and breaks the connection.

All current for signaling and talking is obtained from two sets of 10 cells, each of American Storage Battery of $\frac{54}{J4}$ elements in J7 tanks. This together with

(Concluded on page 643.)

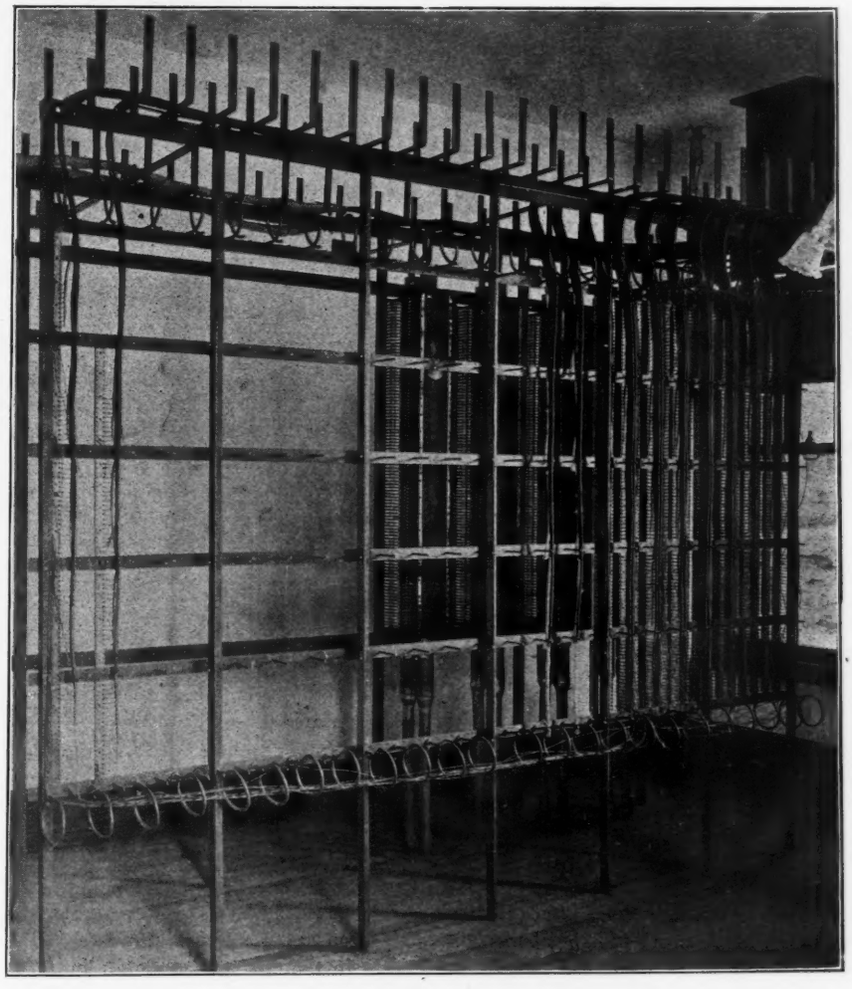


FIG. 4.—DISTRIBUTING FRAMES AND CABLE TERMINAL ROOM.

Fire Delays Brooklyn, N. Y., Car Lines in Rush Hours.

Fire completely destroyed the big Ridgewood power-house and stopped the working of 10 of the most important street car lines in Brooklyn between four and six o'clock in the afternoon on December 4. The fire was discovered in the basement of the big power-house in Wyckoff avenue, near Myrtle avenue, about four o'clock, and D. W. F. Windolaid, the chief engineer, rushed through the smoke, cut off the power connections with the street, and then shut off the engines. There were eight big boilers in the basement, and the consequences of an explosion would have been fearful. Fifteen men worked in the building, and these all escaped in safety and at once began to run out the cars from the big sheds adjoining the power-house. Not a car was lost.

Clinton R. Rossiter, president of the Brooklyn Rapid Transit Company, went to the fire and for an hour great efforts were made to get the tied up car lines running. Connections were made with the other power-houses throughout the borough, and the DeKalb avenue, a rival line, promptly offered to lend some of its power. The offer was gratefully accepted. With all the efforts of the railroad men it was almost six o'clock before the 10 lines were in operation, after a two hours' blockade.

The power-house was 150 feet wide, 100 feet deep and 40 feet high. It was the oldest in the city and was built in 1889, to supply the old Brooklyn City Railroad system. The electric current was supplied to the Myrtle, Gates, Bushwick, Knickerbocker and Flushing avenue, North Second street, Cypress Hills, Lutheran Cemetery, Richmond Hill and Bowery Bay lines. The house burned to the ground and the car sheds next door followed it. The loss will be about $150,000, though much of the machinery and dynamos were of ancient pattern, and new and improved ones can be put in their places for the original cost of those destroyed.

The Huguenot Electric Light, Heat and Power Company has filed a certificate of extension of business and power and rights in Westchester, N. Y. Among other things, it proposes to manufacture gas for supplying light in every township in Westchester; also to supply steam to consumers from a central station, through pipes and conduits, and electricity for power. The capital stock is fixed at $50,000, divided into 500 shares. The directors comprise John J. Crennan, of New Rochelle; F. A. Stratton and C. H. Werner, of New York. The principal office of the company is in New Rochelle.

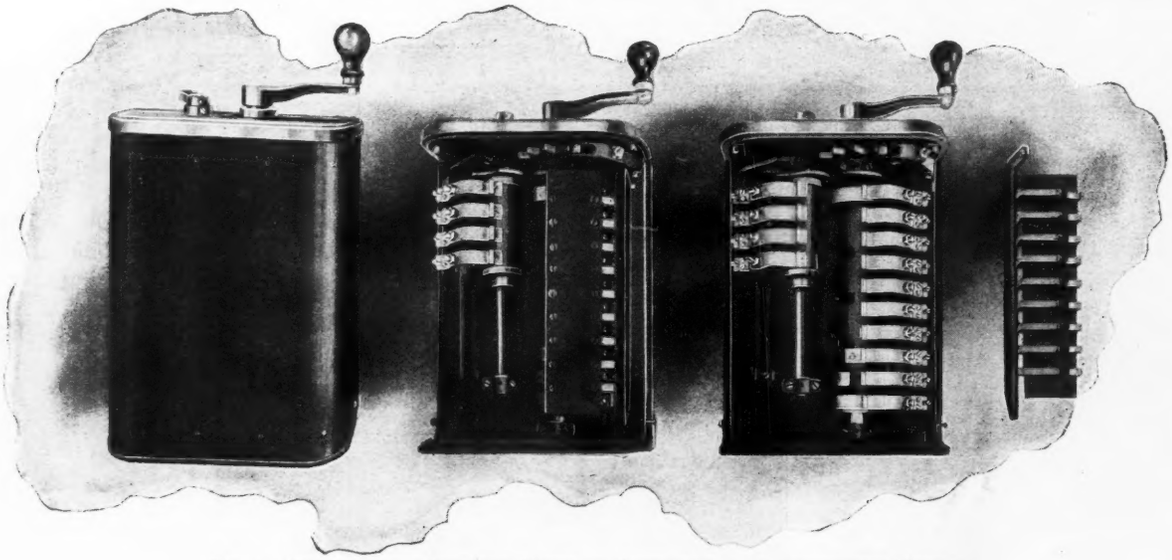


FIG. 1.—EXTERIOR AND INTERIOR VIEWS OF CONTROLLER FOR AUTOMOBILE MOTORS.

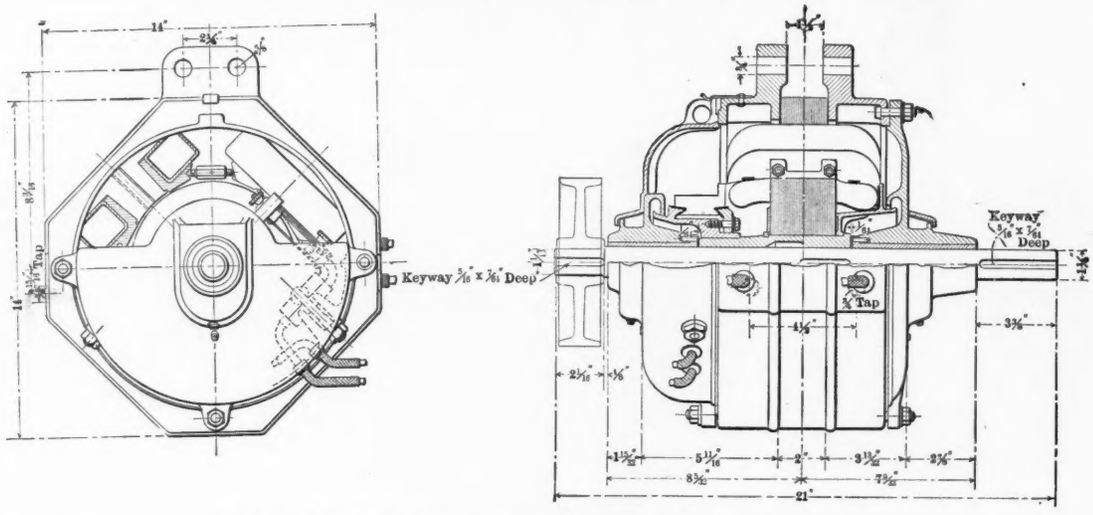


FIG. 2.—END ELEVATION AND AXIAL SECTION OF AUTOMOBILE MOTOR.

Electric Motors for Automobiles.

The requirements of an electric motor for automobile use are peculiar and call for a careful design and calculation of all the parts entering into the structure of the machine with reference to its use. The accompanying illustrations represent motors and auxiliary apparatus designed by Mr. Robert Lundell, and manufactured by the Sprague Electric Company, New York.

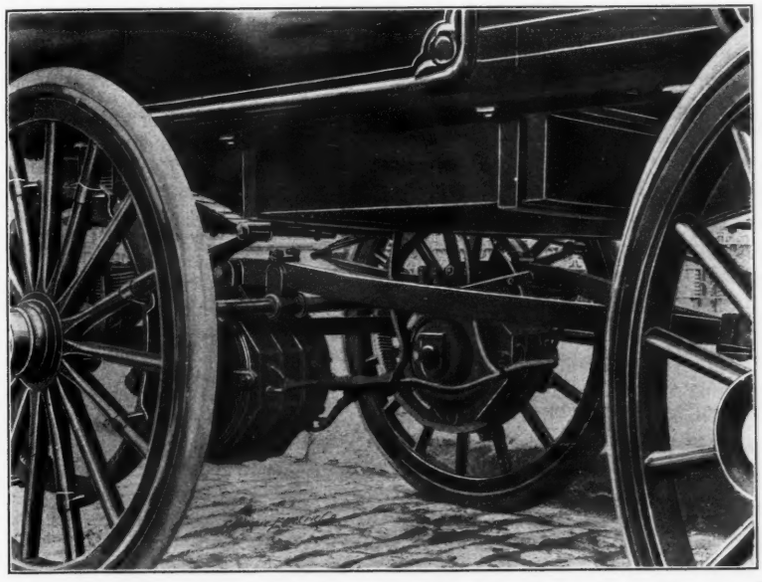


FIG. 3.—AUTOMOBILE MOTORS IN POSITION UNDER VEHICLE.

The motors are known as the "Octagon" type, and are said to be very rigid and free from rattling or shaking of parts. They are made either for single or double equipment as may be desired, in the single equipment the armature winding being double and the motor provided with a double commutator. In this way two commutators are provided for each vehicle, and the advantages of series parallel control may be secured. The motors are wound, usually, for 80 volts, though they may also be wound for other voltages, if required. When the same motor is used for other than automobile purposes, it is furnished with feet, but these are dispensed with in the automobile type, the end castings being furnished instead with lugs or bearings to suit the style of suspension and running gear.

In Fig. 1 is shown a series of views of the exterior and interior of the controller, made with a separate reversing switch, for the larger sizes of automobiles. Fig. 2 is an end elevation and cross-section of one of the octagon type machines of the larger size, provided with a single commutator and intended for vehicles mounted with two motors. The entire field-magnet, with the exception of the pole-tips, is made of laminated sheet iron, while the pole-tips themselves are made of cast iron for the purpose of gradually reducing the magnetic flux at the pole corners in order to secure more accurate and satisfactory commutation. The armature is of the slotted drum type, its winding being of formed coils of square copper wire insulated with great care. The commutator is of the usual copper and mica construction, made large and strong, while the brush-holders are of an exceedingly solid and simple radial type adapted to receive carbon brushes. They are easily accessible by the removal of the end cover of the machine. It has been kept in mind throughout the design that such machines are liable to heavy overloads, and these motors have been built so as to withstand considerable demands upon them.

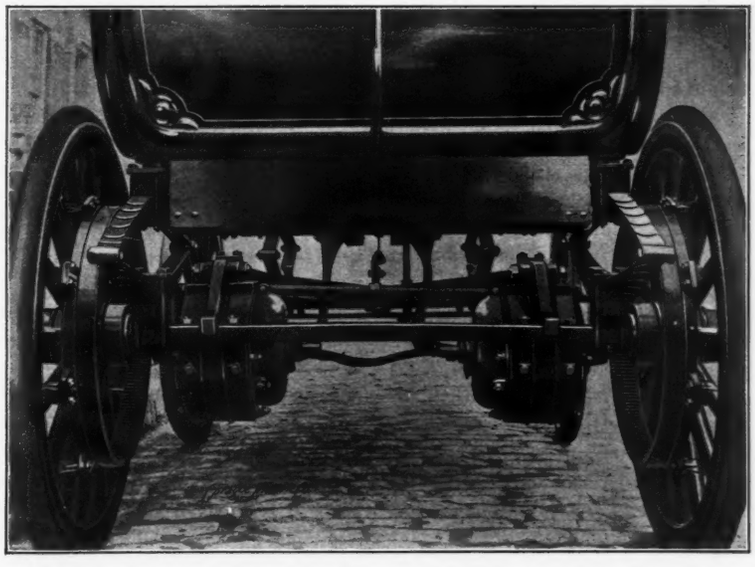


FIG. 4.—REAR VIEW OF VEHICLE TRUCK—SHOWING AUTOMOBILE MOTORS.

Figs. 3 and 4 show views of these motors in place on the truck of a vehicle.

The First Triphase Alternating-Current Railroad in Germany.

The first electric railroad system to use the triphase alternating current in Germany is the recently installed Oberammergau-Murnau line between those two towns, which are 15 miles apart. Starting from Murnau the route of the line is quite level for the first few miles, after which a three per cent grade is reached, which extends for four or five miles. The line ends at Oberammergau, near the theatre in which the Passion Play is given.

The power, which is hydraulic, is taken from a fall in the Ammer River. The power-station is at Kammerl, which is about 10 miles distant from Murnau, and utilizes 1,500 horse-power, supplied by the falls. The Ammer, or Amper, River has been dammed, the water being brought through a canal, 1,500 feet long, to the power-house, the canal terminating in sheet-iron tubes of great diameter which supply three 500-horse-power turbines, which operate the alternating-current generators.

The overhead trolley system is used on the road, which has been built in such a manner that steam engines may be used, as it is expected that the heavy traffic which occurs at the time of the Passion Play, which is presented once during every 10 years, will make it necessary to have additional facilities for handling the tremendous crowds of passengers. During the production of the Passion Play the road will be operated entirely by steam, connections being made with the regular railroads, which will permit the running of international expresses, but under ordinary circumstances the trolley system alone will be in operation.

The Question of Train Lighting.

Among the many minor problems that have been presented for solution by the increase of railway lines and the growth of their equipments is that of lighting railway cars. It may seem, at first sight, as if the lighting of railway cars could present no serious difficulty, but if one examines somewhat the conditions under which such lighting has to be done, he sees that it is a problem of no small difficulty to design and operate an effective and satisfactory train-lighting system.

In the early days of railroads, of course, recourse was had to such illuminants as were then known, and the railway coaches of that time were lighted with candles or whale-oil lamps, and, later, by kerosene. Efforts were made to introduce some system of gas lighting, but for a long time it was found that great difficulties stood in the way. The invention of the Pintsch gas-lighting system, however, solved in a way the gas-lighting problem, and provided a comparatively excellent light, though at a very considerable expense for installation and maintenance.

No sooner was it attempted to distribute a lighting agency such as gas or electricity through a train than it was discovered that whatever variety of light is used each car must be independent of the others, or of the locomotive, so that the accidental or intentional detachment of a car from the train would not interfere with the operation of its lights. Experiments were begun with storage-battery lighting shortly after the introduction of such cells, more than 15 years ago. Among the earlier systems, the simplest, and one that suggested itself immediately, was the illumination of the cars by lights fed from accumulators, each car carrying its own batteries, which were charged at some convenient terminal station. While this system produced, of course, excellent light and is comparatively cheap, notwithstanding, it possesses a serious disadvantage in its entire dependence upon the charging plant, and the fact that a car so equipped can not stay away more than a certain number of hours from its charging plant without its lights becoming extinguished for lack of current. Attention naturally devoted itself, after this experience had been realized to the design of self-contained lighting plants for cars or for trains.

The advantages of electricity as a train illuminant are so conspicuous that they hardly require notice. Producing the steadiest light under the conditions of vibration and drafts of air that exist in railway cars, electricity is at the same time the most manageable light and the safest. The labor of lighting up a car in the case of electricity becomes merely the turning of a switch, while, if the car is wrecked there is left in it nothing whatever to start fire in the wreckage. How far different is the situation of a wrecked car containing a tank of compressed gas or oil-filled lamps many horrible accidents have already testified.

Carrying a dynamo along for the generation of lights was attempted successfully several years ago upon several through trains that were nominally operated as units; for example, the Pennsylvania railroad's fine express trains running between New York and Chicago carried electric illuminating plants as early as 1887. The apparatus consisted of a high-speed, three-cylinder engine, direct-coupled to a small multipolar dynamo, and fed directly from the locomotive boiler, the whole apparatus being placed in a corner of the baggage car nearest the engine. In addition to this generating plant there was also carried under the baggage car a battery of accumulators, and the train was wired throughout on the three-wire system, flexible couplings uniting the cars at the vestibules. This arrangement served excellently for the illumination of solid trains that were not uncoupled. The service of individual cars, however, was another matter, and to it, naturally, the attention of inventors was largely directed.

The accepted system nowadays is one in which power is taken from the motion of the car itself, a dynamo of special construction being driven from an axle by appropriate gearing, and whenever its voltage (increasing with the speed of the car) reaches a certain point it is switched in connection with the battery of accumulators, which it charges, and which is sufficient to maintain the lights for several hours should the car be stationary. While exceedingly simple in design the working out of this system has required considerable study of details and much experiment to bring it to its relatively perfect condition of to-day. It is curious to note that this method of lighting is the cheapest that has been devised.

Of the system in use on the Austrian railways, Herr Cajetan Banovits, ministerial counselor and director of rolling stock and locomotives of the Hungarian State Railways, states in a paper recently read before the International Railway Congress at Paris, that the cost for 10,000 lamp hours was only $2.60. This is far cheaper than lighting by candles, oil, or gas, while the saving of labor in attendance and operation, and the very perfect elimination of danger secured by the use of electricity, makes electric lighting practically the only system to-day worthy of consideration by railway managers. To quote Herr Banovits further:

Its advantages as compared with other methods of lighting may be summed up as follows: Absolutely fixed light, exempt from atmospheric influences, such as wind and cold; facility of being placed according to needs and wishes; possibility of great economy in the lighting by ability to reduce the period of the lighting to the minimum of time consistent with effective need, and even during this period it is possible to notably increase the economy by dimming; its great cleanliness and simplicity of maintenance and also for lighting, lowering or extinguishing the lamps—these operations being made rapidly and without labor and avoiding entirely the inconveniences which lighting from the roof (or ceiling) entails.

Another advantage, not less important, but also extremely valuable, of electric lighting is that the danger of fire, which generally speaking, is not absent from the other methods of lighting, is here entirely excluded. With this method of lighting disappears, in fact, one of the possibilities of danger to which a railroad train is exposed, hence an increase of security in train movement.

All of the inconveniences to which reference has been made are largely compensated for by the advantages cited, and will be more so as the application of this method of lighting is made upon a larger scale, and, as the progress in the manufacture of the accumulators and of the lamps becomes more developed, will end by dissipating, if not entirely, at least in great part, the actual inconveniences.

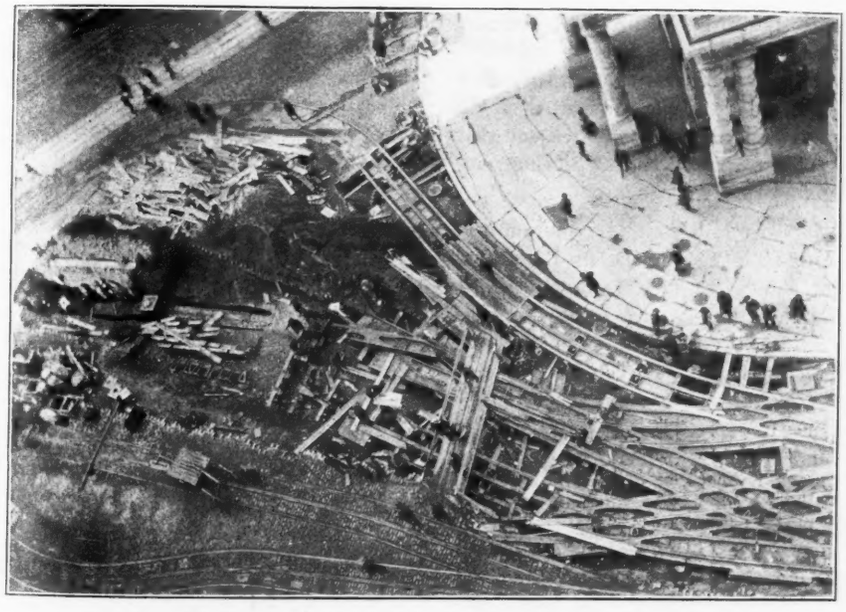
If the engineers of a European railway system, certainly not noted for its progressiveness, so clearly see and appreciate the value of electric illumination in trains, what may we not expect from their alert brethren on this side of the water? It will not be long before electric lighting of trains will be practically universal in the United States, not only because the light is so much better that passengers demand it, but as well because electricity saves the railway management money and is an insurance against loss and damage both to property and person.

OBITUARY.

John B. Faulkner, Jr., died in Washington, D. C., on November 29. Mr. Faulkner had not been in good health for some time and went to Washington to recuperate. While there, typhoid fever developed, and he was ill but a very few days. Mr. Faulkner was purchasing agent for the Electric Storage Battery Company, of Philadelphia, for a number of years, and made many close friends in the electrical trade.

Difficult Construction Work on the Lines of the Third Avenue Railroad Company.

For several weeks past the lower end of Park Row has had much of the appearance of a switch yard. It has been torn up for the purpose of extending the Madison avenue line down Park Row, past the south end of the post office into the Broadway line. The work has been accompanied with considerable difficulty, and it is only by skillful management and the exercise of great care on the part of the construction gangs, that the cars of the Third avenue lines, which run around the loop below the post office, have been enabled to keep up their regular service without any additional inconvenience to the passengers.



THE POST-OFFICE LOOP ON THE THIRD AVENUE RAILROAD, NEW YORK CITY.

Beginning possibly a 100 yards north of the southern end of the post office, on Park Row, the digging and placing of the rails in position has been kept up with persistency, and the work carried on with despatch in spite of bad weather and the heavy crowds of people who are daily compelled to cross Park Row at the very point where the most difficult part of the work was in progress. The excavations which have been made are some five or six feet in depth, enabling the workmen to get under the tracks and put in the conduits and manholes more speedily than was at first anticipated.

In view of the crowds and the congested traffic always in evidence in such a prominent business locality, the heavy materials, the piles of dirt and debris, and the various appurtenances of street railway building have been handled in such a manner that practically no inconvenience of a serious nature has been added to the troubles of the hurrying pedestrian.

The object of the construction is to make the Fourth avenue line a tender of the Broadway road, so that in the Spring, when the Broadway and Columbus avenue lines are changed over from cable to electric systems, the Fourth avenue cars will be enabled to run down Park Row, past the post office, across the Third avenue loop, and all the way down to the battery. Before the electrical equipment of the last-named lines is installed, the Fourth avenue cars will be run as far as the southwestern portion of the loop, where a switchback will make it possible for them to return up Park Row without interfering with or running over the tracks of the Third avenue cars, in much the same manner that they do now at the present terminus of the line near the Bridge. This will, of course, be a great convenience to the passenger, who can thus come all the way down on the east side of the city from One Hundred and Thirty-fifth street without being compelled to transfer, going, if he chooses, as far as South Ferry.

In the accompanying illustration a general view of the work may be seen, showing the condition of the switchback 10 days ago, which was then laid and securely fastened about as far as the curb at the southern end of the post office. The photograph from which the engravings were made was obtained with some difficulty from the balcony of the ELECTRICAL REVIEW offices, on the tenth floor of the Park Row Building, and presents a very fair idea of the condition of the work.

Under the existing conditions, the railroad officials and the engineers who are in charge of the work deserve great credit for the entirely satisfactory manner in which it has been carried on, and which, if the present indications are made good, will be finished within the month.

Courses of Instruction in Electrical Engineering.

Since electricity began to play a prominent part in industrial and commercial affairs in the United States, numerous courses of instruction in electrical engineering have been opened, until to-day there are more than 75 schools which may be fairly said to belong to the better class, in which such instruction is given regularly. A few among these have attained great prominence; for example, Cornell University, Johns Hopkins University, Columbia University, Massachusetts Institute of Technology, Stevens' Institute of Technology, Purdue University, and the University of Wisconsin. The fine equipment of a great Canadian institution is elsewhere described at length and illustrated in this number of the ELECTRICAL REVIEW.

In such schools as those mentioned above the equipment for instruction is of high quality, and has entailed upon the authorities of the schools and upon the beneficiaries of the various institutions a total expense that runs well into the millions. The teaching equipment of a first-class electrical engineering laboratory, such as that of Purdue University, represents a total expenditure which can not be far from a quarter of a million dollars, while each institution maintaining this variety of course must also pay a professor and a number of instructors and assistants.

In addition to the institutions of learning that have been mentioned, and to those in general of the older type, in which a student comes to the school and resides in it during his period of instruction, there have also been established in this country within the past few years several institutions for teaching engineering by correspondence. In the latter class of schools, of which the International Correspondence Schools of Scranton, Pa., the Electrical Engineering Institute of Correspondence Instruction, and the American School of Correspondence are typical, the school comes to the student instead of the student going to school. The success of instruction of this character has been remarkable, and many of the pupils of these correspondence schools have risen to positions of responsibility and importance in the electrical field. In most cases this could only have been accomplished by means of such instruction as they received, and because schools of this character most strongly appeal to young men who are so situated that they must earn their living while they are receiving instruction.

It is not possible to give, with any accuracy, the number of graduates of the various electrical engineering schools in the United States, but this number probably approaches 500 a year.

Electric Lighting

A 250-horse-power, Sioux City Corliss engine is shortly to be installed in Storm Lake, Iowa, to increase the capacity of the electric light plant there.

A company has been formed in Leadville, Colo., with a capital stock of $75,000, to furnish electric light. About $30,000 of this sum is said to be already pledged.

The proprietor of the electric light plant in Bloomville, Ohio, has recently sold the entire equipment and good will to one of the other residents of that town for $15,000.

In the biennial report of the trustees of the Indiana State Normal School, filed with Governor Mount on November 29, was a recommendation for the installation of an electric lighting plant at a cost of about $8,000.

At a recent meeting of the village trustees of Bath, N. Y., the alleged defective lighting service supplied to that town by the Bath Electric Illuminating Company was discussed and the company was given two weeks in which to correct the evils.

Electric light will soon be supplied to the residents of Great Neck and Thomaston, L. I., by the Arcadian Electric Light and Power Company, of Manhasset, which has been granted permission to extend its service to these places under the direction of the Nassau County engineer.

A new electric light plant is soon to be installed in Tillamook City, Ore., to succeed the present system, which has been running for several years and has outlived its usefulness. The city will be in darkness for several weeks as the old plant was closed down on November 13.

Extensive improvements are to be inaugurated soon by the city of Blue Island, Ill. The old street lighting system is to be replaced by a thoroughly modern alternating current arc and incandescent service, both using the same current, the station voltage of which will be 2,000, regulators and transformers being used.

A charter has been issued to the Marietta, Williamstown & Parkersburg Electric Light and Railroad Company, at Wheeling, W. Va., for the purpose of building an electric railroad from Marietta, Ohio, to Williamstown and Parkersburg, in West Virginia, and also to furnish light to the cities named.

Specifications have been handed in to the common council's committee, of Richmond, Ind., by an Indianapolis engineer for the establishment and equipment of an electric light plant to cost $150,000. The plant will be located to the east of the city near Glen Miller Park. The figures named include the cost of the building.

The municipal electric lighting plant of Harlem, Ill., is to be enlarged and greatly improved in the next few months, a Chicago firm having already secured the contracts. This same company has been awarded the new plants at Rio, Wis.; Napanee, Ind., and Cuba, Ill., all of which are to be put in service as speedily as possible.

Hawesville, Ky., is a very dark town at present as the electric light plant was recently destroyed by fire, and Delphos, Ohio, suffered a similar loss in the burning out of its largest dynamo on November 18. The local report stated that the town was in darkness for a week and that the police force had been accordingly increased.

A joint power-house and restaurant is to be erected in the Spring at Bay Berry Point, Bay Shore, L. I., to supply electric light and heat, the idea being to enable the residents and owners of the 10 houses which constitute the colony to dispense with cooks and similar servants during the Summer season. The cost is estimated at about $6,000.

A press report from the West says that Chicago has been experimenting with the desirability of using red globes on arc lights in the neighborhood of fire-alarm boxes, and green globes on lights near police-patrol boxes. It is asserted, however, the scheme will not be established generally, as the lamps do not afford sufficient street illumination when the globes are thus tinted.

A proposition has been submitted to the common council of Jamestown, N. D., for the erection and equipment of an electric light plant, which was rejected by the city officials, who determined to draw up an ordinance agreeable to the city and submit it to all who desired to build a plant. At the present time one company has a monopoly of the lighting and a majority of the citizens is in favor of permitting another company to compete.

A Danish electrical engineer has recently invented an electric lamp which, it is stated, will considerably advance the methods used by Professor Finsen in his electro-therapeutic treatment. A description of the lamp appears in the *Elektroteknisk Tidsskrift,* which states that the light has been tested at "Finsen's Hospital for Treatment with Light," in Copenhagen, and has been proved to produce in an especial degree those chemical rays which are necessary for the purpose.

Señors Jiminez & Company, of Matanzas, Cuba, are soliciting proposals for an electric light plant and traction system to be installed in that city. The lighting plant must have a capacity of not less than 225 1,500-candle-power arc lamps with sufficient reserve energy to supply at least 15 per cent more lamps. Bonds to the amount of $3,000 will be required from the successful contractor (American gold) as security for the faithful performance of his obligations.

Newspaper reports from Delaware state that New York capitalists have purchased and will shortly assume entire control of the Universal Conduit Heat, Light and Power Company, of Wilmington. Conduits are soon to be laid in the streets, which will be opened for that purpose within a week or so, and the power-house for the lighting station erected before the Summer. The franchise for opening the streets was given to the old company and deeded over with the other property. Just the amount of the purchased price is not stated, but it is believed to reach a considerable figure.

The electric light company of Atlantic City, N. J., recently cut its own wires to permit the moving of a house across the street, the wires being in the way at the time. After the last car of the trolley company had gone past the house a gang of men from the traction company cut the trolley wires. They were followed in a few minutes by the lighting company's men who, in a short time, had their own wires down, the house movers meantime being at work shifting the cottage. The work was all done without any inconvenience to the patrons of either company, and the wires of both trolley and electric systems were replaced before dawn.

High water in Lake Kearney, an artificial waterway north of the city of Kearney, Neb., caused damage to the amount of $20,000 to the large brick power-house of the city electric company, practically ruining it. An inflow of water was discovered early in the morning at the mouth of the iron flume, which supplied a small water-wheel in a building west of the main part of the power-house. This increased rapidly until a wide chasm was opened up from the canal to the power-house, ripped up the first and second floors, made short work of the annex and swept away a large

portion of the north wall, tearing out a turbine and an arc-light dynamo. All the new and expensive electrical machinery which the company had recently installed is said to be wrecked beyond repair.

A curious theft was recently reported in New York city, the loser being the Edison Electric Illuminating Company, of 53 Duane street. An inspector of the company, while making his regular rounds through Chinatown, discovered that the Celestials were working a very ingenious scheme by which their stores and laundries had been lighted for the past four months practically free of charge, the electric meter being the victim of their conspiracy. Between the magnet and the registering disk of the meter was inserted a small paper wedge which prevented the disk from registering, although it did not interfere with the supply of current. The inspector claims that the company lost about $1,000 by the practice, and the nine Chinamen in whose places the fraud had been perpetrated were held for trial in $200 bail.

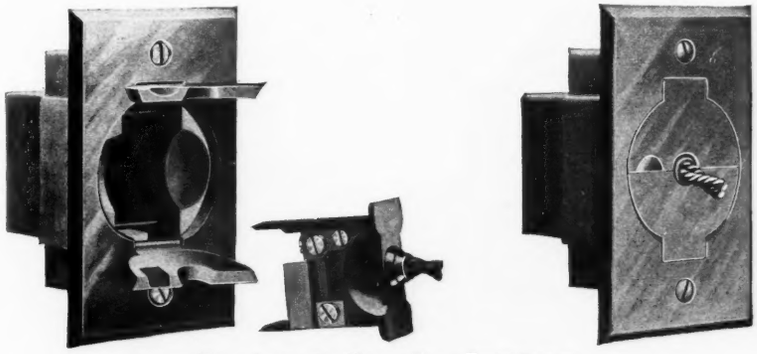
Before the year is out the county buildings of Cleveland, Ohio, will be equipped with a complete electric lighting plant, and it is estimated that a considerable portion of the expense of lighting the court house and jail will be materially reduced. At present about $12,000 a year is paid for gas and electric light, and the county commissioner has said that from what he can learn the charge is exorbitant, the bills for the court house and jail being about $2,000 a year too much. The charges for illuminating the other county buildings are in proportion.

Through a misunderstanding, the bids made by the Roslyn, L. I., Light and Power Company for lighting that village were refused by the town board, and other bids called for. It is believed that Roslyn will have electric lights in the near future and that all the conditions are favorable for such a service.

An Improved Flush Plug Receptacle.

The accompanying illustrations represent a new and greatly improved form of flush receptacle and plug manufactured by Messrs. Zimdars & Hunt, of 127 Fifth avenue, New York city.

The face-plate is removable and binding-posts are provided at the top of the receptacle. This construction permits the wire connections to be made quickly and easily when the receptacle is in place. The plug has fuse connections and is provided with knife blades fitting into substantial clips in the base of the receptacle and making an excellent contact of considerable area. The peculiar arrangement of the receptacle doors and the plug, which permits the doors to be closed over the plug when it is in place, and which is a distinguishing feature of the apparatus made by this house, is retained in this new device.



FIGS. 1 AND 2.—FLUSH PLUG RECEPTACLE.

A Combination Electric Fountain and Tableaux-Vivants.

An electric fountain of decidedly novel type has been installed in Heine Park, Kansas City, Mo., combining the usual features with an unusually novel scheme for giving tableaux-vivants.

In the centre of the fountain a platform has been built which accommodates the persons who will represent famous statues, groups, and other historical works of interest. Outside of this platform is a circle of jets which are illuminated by colored electric lights, the space in the centre being dry. In addition to the tableaux pyrotechnic displays will be a feature of this novel institution, being used in connection with aquatic figures.

The plant of the Winona, Ill., Light and Power Company has been combined with the Spring Valley Electric Light Company, the former concern being the purchaser. The new owner will at once institute important repairs on the recently acquired property, as at present it is considerably run down.

Combined Tenders.

Under the above title the London *Electrical Review* prints the following interesting communication from M. Ch. Leven:

It is with interest that I note your editorial on the above subject in the issue of October 26, which I have only just seen, on account of my absence on the Continent.

I fully agree with you that the stand you take should be most beneficial to buyer as well as to seller. As a seller of dynamos, I am often hampered by having to furnish a complete plant, consisting of steam-engine, piping in some cases, dynamos, etc., and, as you rightly state, the electrical part is comparatively small to the total, but still the electrician has to furnish something he does not make, simply because the public has been accustomed to inquire of the electrician for the complete plant.

As a matter of course, nobody would furnish machinery and take the responsibility of same without being paid for it; and if, therefore, the dynamo builder has to furnish the plant, he has to make a profit on the steam part, and *vice versa*.

I have just been told that in Germany the electrical companies have agreed not to furnish a steam-engine with a plant without adding five per cent of profit to same. This is a very good idea, as not only does it put everybody on a fair basis, but it also gives the buyer the advantage of buying it himself without paying the additional five per cent.

From the buyer's standpoint, however, it may seem that he only wants to hold one man responsible in case of the plant not coming up to its requirement; but if he is dealing with responsible firms, there should be no difficulty whatsoever in settling the point as to who is to blame if anything is wrong.

I remember a case where a plant was erected consisting of a compound dynamo and a high-speed horizontal engine. When the motor load was put on all the lights went down, and when the load was taken off up went the lights. The engine builder insisted that the dynamo was not properly compounded, and the electrician claimed that the engine did not regulate properly. The dispute was, of course, easily settled, and the engine, which did not govern as guaranteed, was taken out and replaced with one that did.

I dare say that if a dispute should arise in a case where the engine and dynamo were furnished separately by different contractors the same could easily be settled by arbitration.

I repeat what I said in an article on this subject which I wrote some years ago for the ELECTRICAL REVIEW in New York, *viz.*, that I do not see why a dynamo builder should furnish steam-engines any more than a coach builder should furnish horses.

Jerseyville, Ill., is soon to have a new electric light plant which will supply energy for arc and incandescent house and street lighting.

THE INDEPENDENT TELEPHONE EXCHANGE AT EAST LIBERTY, PA.

(Concluded from page 641.)

the power plant is located in the main floor. The power equipment shown in Fig. 3 consists of one Wagner single-phase alternating-current motor, running from 104-volt mains, and giving two horse-power at 1,750 revolutions per minute. To this are belted two three-quarter horse-power Roth generators running at 1,400 revolutions per minute, giving 10 amperes at 28 volts and designed to charge 10 cells of storage battery. The machines are mounted on a power table, the sides of which are enclosed, concealing the wiring beneath. Upon the front panels are placed the starting boxes and field rheostats. The power switchboard is of slate, 42 by 45, supported by an iron framework. Two I. T. E. series circuit-breakers are provided with underload and overload attachments, and two single-throw, five double-throw, 90-ampere, double-pole, back-connected switches with Jewel ammeter and voltmeter.

To the left of the power boards, Fig. 3, is shown the fuse board and repeating coil rack, which is made as dust proof as possible by being encased in a wooden frame with glass doors. Fuses are provided for the leads both to and from the repeating coils on the line side as well as the return side of the battery.

The line cables enter the building at the basement and are carried in lead-covered sheaths to the cable terminal heads, whence they are led in 21 pair cables to the distributing frame and from there to the switchboard sections. The cable heads and distributing frame are shown in Fig. 4. The framework of the distributing board is of iron. The distributing frame has a capacity of 2,400 lines and is at present equipped with terminals for 920. The switchboard terminals and line terminals are arranged in alternate vertical rows of 100 lines each.

Throughout this exchange the woodwork is mahogany, which, with the nickel-plated metal work, gives a very rich and pleasing appearance. With five other branch exchanges, located at Allegheny, South Side, Bellefield, Manchester and Lawrenceville, and the main exchange at Pittsburgh, this exchange forms part of a system whose present equipment is over 7,000, with an ultimate capacity of over 16,000, making it one of the largest and most complete equipments in the independent telephone field. Of the branch exchanges, Allegheny is of the same general type as the one just described, while the remaining four are equipped with the Kellogg "Universal" switchboard, having 240 lines equipped and an ultimate capacity of 1,200 lines each. All are designed for use with the common battery system.

Wall Street and the Electrical Stock Market.

On the New York Stock Exchange, General Electric closed the week at 169⅝ bid and 170 asked, showing a gain of 2⅛ points. Metropolitan Street Railway, of New York, closed 164¾ bid and 165 asked, indicating a loss of 6¼ points. Brooklyn Rapid Transit closed at 70¼ bid and 70½ asked, showing a loss of 1¼ points for the week. Third Avenue Railroad closed at 114½ bid and 115 asked, showing a gain of 1½ points. Manhattan Railway, of New York, closed at 107⅞ bid and 108 asked, indicating a loss of 1⅛ points for the week.

PROFESSOR R. B. OWENS, IN CHARGE OF THE ELECTRICAL DEPARTMENT OF MCGILL UNIVERSITY.—(See page 626.)

On the Boston exchange, American Telephone and Telegraph closed at 155½ asked and no bid price quoted, showing a loss of 3½ points in the asked price. Erie Telephone closed at 104 bid and 106 asked, indicating a loss of 3½ points for the week.

On the Philadelphia exchange, Electric Storage Battery was not quoted. Electric Company of America closed the week at 8⅞ bid and 9 asked, showing a loss of 1⅛ points. Union Traction closed at 34½ bid and 34⅝ asked, indicating a gain of ¼ point for the week.

On the curb, or outside market, in New York, Electric Vehicle closed at 19½ bid and 20 asked, showing a gain of 2½ points. Electric Boat closed at 23 bid and 24 asked, showing a gain of 5 points for the week. Consolidated Equipment closed the week at 11½ bid and 11¾ asked, showing a loss of 2¾ points.

Wall street, December 8.

General Electric Increased Dividend.

The General Electric Company declared on Monday of this week a quarterly dividend of two per cent on its common stock, and an extra dividend of one per cent, payable January 15.

Annual Meeting American Society of Mechanical Engineers.

The forty-second meeting of the American Society of Mechanical Engineers was held at the clubrooms, 12 West Thirty-first street, New York, from December 4 to 7. The meeting was formally opened on Tuesday evening with President Morgan's address. On Wednesday morning at ten o'clock the society again convened and papers were read and discussed. In the evening, there being no afternoon session, four papers were heard, among which was Mr. F. W. Dean's treatise on the "Power Plant of the Massachusetts General Hospital."

On Thursday morning the society accepted the invitation of President Seth Low, of Columbia University, meeting in the lecture room of Havemeyer Hall, after which the University was inspected, the day concluding with a reception at Sherry's at nine o'clock, supper being served from 10 to 12. On Friday, five papers were presented and discussed, after which the meeting was declared adjourned.

At the business session the following officers were elected, the 620 votes being cast by letter: President, Samuel T. Wellman, of Cleveland; vice-presidents, David Townsend, Philadelphia; Stevenson Taylor, Hoboken; Jesse M. Smith, New York; Arthur M. Waitt, New York; James M. Dodge, Philadelphia, and Ambrose Swasey, Cleveland; managers, Edgar C. Felton, Harrisburg; A. M. Goodale, Waltham, Mass.; R. H. Soule, New York; Francis H. Boyer, Somerville, Mass.; John A. Brashear, Allegheny, Pa.; Alfred H. Raynal, Washington, D. C.; W. F. M. Goss, Lafayette, Ind.; De Courcy May, Scranton, and D. S. Jacobus, Hoboken, N. J.; treasurer, William H. Wiley, New York.

A paper was to have been presented by Cornelius Vanderbilt, Jr., but that gentleman sent word that he had been unable to collect the data necessary for the proper exploitation of his subject. The society appointed a committee to prepare a standard for boiler rules and it was decided to erect a monument to Robert Fulton in Old Trinity Churchyard, the site alloted being on the Rector street side close to the grave of Alexander Hamilton. A columned sarcophagus is to be the form of the memorial. Twelve members were announced in the annual report read at the opening session as the representatives of the society at the Engineering Congress of next August, which will be held in Glasgow, Scotland. These were S. T. Wellman, C. H. Morgan, George W. Melville, James Dredge, Sir Benjamin Baker, W. C. Unwin, H. F. Parshall, Philip Dawson, Bryan Donkin, H. F. L. Orcutt, O. H. Baldwin, and Alexander Sahlin.

THE THEORY OF ALTERNATING DYNAMO-ELECTRIC MECHANISMS—VII.

BY W. ELWELL GOLDSBOROUGH.

ON THE POWER DEVELOPED IN ALTERNATING-CURRENT CIRCUITS.

In determining the power generated by an alternating-current machine, or in estimating the rate at which energy is imparted to any alternating-current system, we must formulate an equation that will express the rate at which work is being done at any instant of time; then, after integrating between the limits desired, divide by the intervening time to ascertain *the mean rate* at which power is developed.

If an electro-motive force, acting upon a circuit, creates a current (i), energy will be imparted to the circuit at the rate of ($e\,i$) watts, or ($e\,i$) joules per second, since one watt equals one joule per second; and since, whatever be the forms of the functions expressing their instantaneous values, (e) and (i) can be considered as constant during the infinitesimal time ($d\,t$), the product,—

$$e\,i\,d\,t = (\text{work in joules}) \qquad (63)$$

will equal the work given to the circuit during this time.

The general equation of energy of a circuit containing resistance and self-induction will, therefore, be of the form,—

$$e \cdot i \cdot d\,t = i^2 r\,d\,t + \mathrm{L}\,i\frac{d\,i}{d\,t}d\,t \qquad (64)$$

obtained by multiplying equation (57) by ($i \cdot d\,t$). Here $e \cdot i \cdot d\,t$ is that part of the energy of the source which is used up during the time ($d\,t$) in developing ($i^2 r\,d\,t \times .24$) calories of heat in the conductors of the circuit, and in expending ($\mathrm{L}\,i \cdot d\,i$) joules upon the inductive portion of the circuit.

If (e) and (i) are simple harmonic functions of the time we can write (64) in the form,—

$$e \cdot i \cdot d\,t = [\mathrm{E}\sin\omega\,t]\,[\mathrm{I}\sin(\omega\,t-\phi)]\,d\,t \qquad (65)$$

$$= \mathrm{EI}\sin\omega\,t\sin(\omega\,t-\phi)\,d\,t$$

$$= \frac{\mathrm{EI}}{2}[\cos\phi - \cos(2\,\omega\,t-\phi)]\,d\,t \qquad (66)$$

since

$$\cos(\theta+\theta') - \cos(\theta-\theta') = -2\sin\theta\sin\theta'. \qquad (67)$$

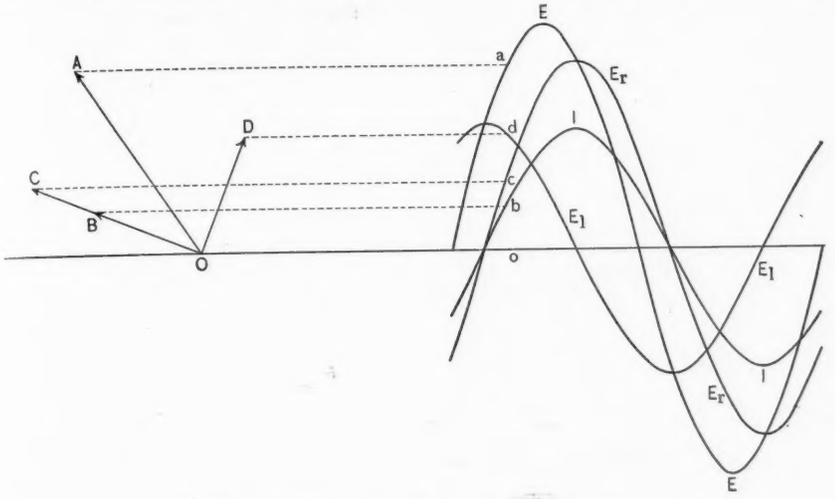


FIG. 22.—ALTERNATING-CURRENT MECHANISMS.

By integrating (66) between the limits (O) and (T), we get,—

$$\int_0^{\mathrm{T}} e \cdot i \cdot d\,t = \frac{\mathrm{EI}}{2}\cos\phi\int_0^{\mathrm{T}} d\,t - \frac{\mathrm{EI}}{2}\int_0^{\mathrm{T}}\cos(2\,\omega\,t-\phi)\,d\,t$$

$$= \frac{\mathrm{EI}}{2}\mathrm{T}\cos\phi \text{ joules}, \qquad (68)$$

since

$$\int_0^{\mathrm{T}}\cos(2\,\omega\,t-\phi)\,d\,t = -\frac{1}{2\,\omega}[\sin(2\,\omega\,t-\phi)_0^{\mathrm{T}} = 0.] \qquad (69)$$

Equation (68) is a measure of the energy imparted to the circuit *during one period* and if we divide (68) by (T),

$$\text{The mean power} = \mathrm{P} = \frac{\mathrm{EI}}{2}\cos\phi, \text{ watts}$$

= the rate at which power is imparted to the circuit, (70)

$$= \frac{\mathrm{EI}}{2}\cos\left(\tan^{-1}\frac{\mathrm{L}\,\omega}{r}\right) = \frac{\mathrm{EI}\,r}{2\sqrt{r^2+\mathrm{L}^2\omega^2}} \qquad (71)$$

Since (E) is the maximum value of the impressed electro-motive force, (I) the maximum value of the current, and (ϕ) the angle of lag of the current, we find that,—

The power developed in *any* alternating-current circuit is equal to one-half the product of the maximum impressed electro-motive force and the maximum current of the circuit *multiplied by the cosine of the phase angle* between them, *when the quantities involved are sine functions.*

Returning now to the triangle of electro-motive forces shown in Fig. 20, we will reproduce them in Fig. 22, together with their corresponding sine curves representing their instantaneous values for successive increments of time during one revolution, and if we take the products of each of the electro-motive-force ordinates and the corresponding ordinates of the current curve, it is evident that we can plot, with these products as ordinates to the same time increments as abscissae, three power curves showing the exact relation of each of these forces to the energy spent in the circuit.

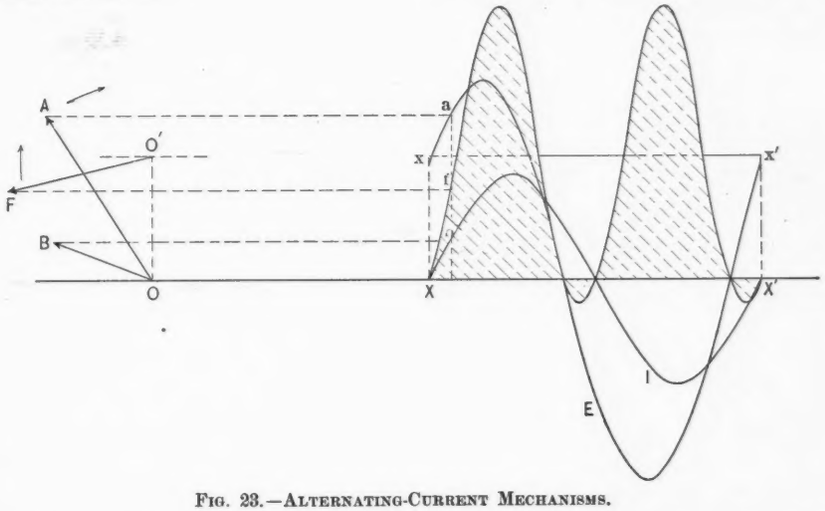


FIG. 23.—ALTERNATING-CURRENT MECHANISMS.

The first of these, shown in Fig. 23, represents the energy expended upon the circuit by the impressed electro-motive force. The shaded areas above the line represent the energy *expended on the circuit* during one period, and the shaded areas below the line the energy *given back to the source by the circuit*, and *the difference between these areas measures the useful work done*, which as found above is equal to,—

$$[\mathrm{T}\ (\mathrm{EI} \div 2)\cos\phi.] \qquad (68)$$

Corporation News

PIERRE, S. D.—The Tyndall Telephone Company was incorporated, on November 29, by local capitalists for $2,500.

HARRISBURG, PA.—The Mayfield Electric Light, Heat and Power Company has been capitalized and chartered for $5,000.

RICHMOND, VA.—A $200,000 company will soon be organized in Norfolk by D. R. Creecy and others to promote a telephone system.

COLUMBUS, OHIO—The Harrison Telephone Company, of Hamilton County, has been incorporated by local interests with $5,000 capital.

NASHVILLE, TENN.—A charter has been granted to the Citizens' Telephone and Construction Company, which has been organized with $10,000 capital stock.

SPRINGFIELD, ILL.—The American Battery Compound Company, of Chicago, has been organized with a capital stock of $2,500. Its incorporators are all Chicago parties.

JEFFERSON CITY, MO.—Among recent incorporations is that of the Cass County Telephone Company, of Harrisonville. The capital stock of the new corporation is $2,000.

NASHVILLE, TENN.—Among recent incorporations in Tennessee is that of the Bristol Light and Power Company, which has received a charter and is capitalized at $25,000.

EASTON, PA.—Articles of association have been filed at the Easton court-house for the Bangor, East Bangor & Portland Street Railway Company, with a capital stock of $12,000.

HUNTINGTON, PA.—The Huntington & Clearfield Telephone Company has been chartered with a capital of $1,000, and will build a telephone line through seven counties of the state.

ERIE, PA.—Articles of incorporation have been granted to the Terminal Street Railway Company, with a capital of $7,500, to build a trolley line in Erie one and one-quarter miles long.

BOSTON, MASS.—The consolidation of the Brockton & Plymouth, Pembroke, and the Plymouth & Kingston Street Railway companies is now complete, the present capitalization being $270,000.

SHERIDAN, IND.—The Central Indiana Telephone Company, of this city, was incorporated, on November 21, at Indianapolis, for $10,000, to erect and operate telephone lines.

MARION, IND.—The Mead Electric Company has been organized by Messrs. Mead and Keller, of Marion, with a capital stock of $100,000, to supply electricity for heat, light and power.

GERING, NEB.—The Gering & Southern Railroad Company has been incorporated for $25,000, with E. W. Sayre, president; R. F. Neeley, vice-president; H. M. Thornton, secretary, and Martin Gering, treasurer.

CHESAPEAKE CITY, MD.—It is reported that $80,000 of the $150,000 capital stock of the Cherry Hill, Elkton & Chesapeake City Electric Railway Company has been subscribed in a lump sum by Philadelphia capitalists.

SOUTH WHITLEY, IND.—A company which will operate a telephone exchange has been incorporated recently under the name of the South Whitley Telephone Company with a capital of $3,000, by local merchants.

WILMINGTON, DEL.—On November 23 a charter was issued to the Philadelphia Messenger Telephone Call Company, granting it the privilege of using electricity in all its branches. The capital stock is $100,000.

ALBION, IND.—A telephone company, to be known as the Noble County Telephone Company, has been incorporated in Indianapolis for the purpose of operating a telephone exchange. Its capital is $15,000, subscribed entirely by local interests.

FORT WAYNE, IND.—The Indiana & Ohio Traction Company has been organized and incorporated with a capital of $750,000 by Indiana, Ohio and Pennsylvania capitalists. It will construct and operate electric lines within the two states mentioned.

ST. PAUL, MINN.—Among the charters granted by the secretary of state, on November 26, was that of the Ada Telephone Company, whose object is to operate telephone lines. Its capital is $1,000, and the incorporators are from Ada, Gary, and Twin Valley.

NEWARK, N. J.—The American Steel Railway Generating and Power Company has been incorporated, at Trenton, for $2,500,000 to carry on the business of electrical and mechanical engineers, manufacture and deal in electricity for motive power, heat and light.

MONTREAL, CANADA — The Canadian Electric Company, of Peterboro, Ont., has obtained control of the Royal Electric Company, of this city, for a consideration of $750,000, thus practically obtaining a monopoly of electrical manufacturing of the Dominion of Canada.

DES MOINES, IOWA—A charter has been granted to the Dyersville Light and Water Company, which is capitalized at $15,000, and an amendment to its articles has been filed by the Des Moines Edison Lighting Company, certifying to an increase of its capital stock from $450,000 to $1,250,000.

LONDON, ENGLAND—A despatch by cable to New York says that the Hempstead Tube Company, Mr. Charles T. Yerkes's company for the construction of an underground electric railway, has formally registered its capital at £1,000,000. It is said that none of the stock will be floated in London.

YOUNGSTOWN, OHIO—An increase of $4,000,000 to the capital stock of the Youngstown & Sharon Electric Railway Company was voted by the stockholders on November 20. This increases the capital of the company to $6,000,000. New York capital is said to be heavily interested.

COLUMBUS, OHIO—Charters were granted, on November 26, to the National District Telephone Company, capitalized with $1,000, to construct a telephone system, and the Citizens' Telephone Company, of Xenia, organized for the same purpose, with a capital of $125,000.

HOCKING VALLEY, OHIO—Articles of corporation have been granted to the Athens, Marietta & Hocking Valley Traction Company, which has been incorporated for $100,000, and will build an electric line from Athens to Logan, through Athens and Hocking counties. Light, heat and power will also be furnished.

DEKALB, IND.—A change in its name has been instituted by the Sycamore & DeKalb Electric Railway Company, which will continue its operations under the name of the DeKalb County Light, Heat and Traction Company. Its main offices will be changed from Sycamore to DeKalb and two additional directors put on its board, bringing the number up to five.

PATCHOGUE, L. I.—Twenty of the citizens of this town are said to have agreed to purchase the rights, title and interests of the Patchogue & Port Jefferson Traction Company, which was formed some time ago to build an electric railroad across the island between intermediate towns. The purchasers will endeavor to effect the construction of the road.

PHILADELPHIA, PA.—The lease of the properties of the Easton Consolidated Electric Company to the Lehigh Valley Traction Company was ratified on November 30, in Camden, N. J., the lease providing for an annual rental of $45,000, which is equivalent to 10 per cent of the amount paid in on the stock of the Easton Consolidated, which will be practically $15 a share after the final call has been made.

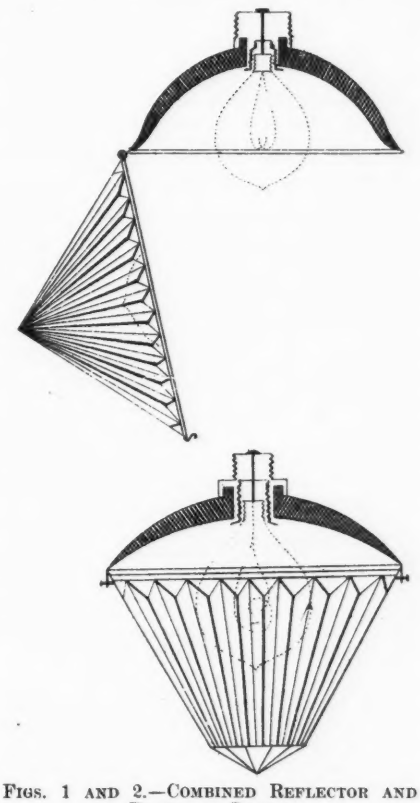
TECUMSEH, OKLA. TER.—A new corporation, with a capital stock of $1,000,000, to be known as the Oklahoma Telephone and Railway Company, has recently been granted a charter and intends to build an electric line from Tecumseh to Coalgate, I. T., passing through Pauls Valley, Roff and Stonewall. Another line will be run from near Pauls Valley to Sulphur, where the line divides and runs west to Davis, terminating at Hickory, both in the Indian Territory. The estimated length of both lines will be 125 miles, and will cost about $100,000. In connection with the traction system the company will operate an electric light plant for each road and illuminate all the towns on its lines.

Views, News and Interviews

During the recent storm that swept along the Atlantic coast a four-masted schooner, endeavoring to get into Vineyard Sound from the westward, threw out her anchor to avoid being driven on shore and caught the submarine cable belonging to the Martha's Vineyard Telegraph Company, connecting Pasque Island and the western end of Martha's Vineyard, and broke it in two places. The gales and heavy seas, which continued for nearly a week, prevented the repairs of the cable, but on November 25 the cable ship Western Union succeeded in taking up, repairing and relaying the cable, which is a two-conductor, and seven miles long. This cable was originally laid by the Government Signal Office to establish communication between Woods Hole, Martha's Vineyard and Nantucket. Last June the lines were sold by the Government to Mr. George C. Maynard, of Washington, D. C., and have since been transferred to the Martha's Vineyard Telegraph Company, an incorporation organized under the Massachusetts statutes with Mr. Maynard as president and general manager. Through the lines of this company, communication is maintained with Naushon, Pasque, Cuttyhunk and all points on Martha's Vineyard and Nantucket. Mr. Maynard is, this week, at Woods Hole opening a new office of his company which will be operated in connection with both the Western Union and Postal companies. This expedition of the Western Union is its second Winter trip to Vineyard Sound. Recently it laid the large cable of the New England Telephone Company between Nobski Point and East Chop, a full account of the expedition being published in the ELECTRICAL REVIEW at the time.

"An imported domestic in one of Detroit's prominent households has delivered an ultimatum on the subject of telephonic duties," remarks an exchange. "The mistress of the house, after an absence of a few hours, recently asked the unsophisticated maid if any one had called her up on the telephone. She replied: 'Indade they did, mum. The box jingled an' a lady wid a voice like a coffee mill says, 'Hello!' an' I says, 'Hello yerself;' an' she says, 'Who is this?' an' I says, 'None of yer business.' An' she says, 'Is Aunt Mary there?' An' I told her she'd betther ask a policeman, an' she foired sumthin' in my ear, an' I dared her to show the ugly mug of her back of our barn an' she said nuthin.' I'll talk in that machine no more, mum.'"

"The average telegraph office is a very peculiar institution," says the *Telegraph Age*, "and has been visited by a great many who were in search of an express office, a shoe shop, a lunch counter, a shooting gallery and a lager-beer saloon. It sounds odd, at least, to have a person enter a telegraph office and ask for a glass of beer."



FIGS. 1 AND 2.—COMBINED REFLECTOR AND DIFFUSING SHADE.

Combined Reflector and Diffusing Shade.

An interesting novelty in electric light fittings is illustrated in the accompanying engravings, which show a new combined reflector and shade, of German manufacture, in two positions. The device is made of two parts, the upper curved hemispherical portion being of pressed glass silvered, and acting as a reflector, while the conical portion below is of cut glass, the prism-like edges of which serve to distribute the light uniformly over the area below the lamp. By the use of the reflecting hemisphere the otherwise wasted light of the lamp, which would shine upwards, is utilized, while the distributing prisms add greatly to the softness and beauty of the light. The apparatus is imported into this country by Mr. F. Euler, 35 Broadway, New York city.

ELECTRIC VEHICLE COMPANIES CONSOLIDATED.

THE ELECTRIC VEHICLE COMPANY ABSORBS THE RIKER MOTOR VEHICLE COMPANY.

The Electric Vehicle Company has bought the entire $4,000,000 capital stock of the Riker Motor Vehicle Company, of Elizabethport, N. J., and will probably increase its own preferred and common stock by $1,000,000 each. Mr. George H. Day has been elected president of the Electric Vehicle Company, succeeding Mr. Robert McA. Lloyd, who remains a director. Mr. F. C. Stevens, president of the Metropolitan Street Railway Company, of Washington, D. C., who has been the president of the Riker company, has been made a director of the Electric Vehicle Company. Mr. H. M. Byllesby, first vice-president of the Riker company, has been made first vice-president of the Electric Vehicle Company; and Mr. W. H. Johnson, who has been general manager of the Electric Vehicle Company, has been elected its second vice-president. Mr. A. L. Riker, second vice-president of the Riker company, has been chosen third vice-president of the Electric Vehicle Company. He will also have charge of the company's designing department. Mr. Arthur Phillips, who has been the secretary of the Electric Vehicle Company, has been replaced by Mr. T. W. Goodridge, of Hartford. Mr. Frederick Viewig has been elected treasurer. At his request, the place in the board of directors formerly occupied by John Jacob Astor has been filled by Mr. George Chapman, his business representative. Besides the gentleman named above, the new board of directors consists of Messrs. P. T. Dodge, Herbert Lloyd, Martin Maloney, Colonel A. A. Pope, T. J. Regan, Isaac L. Rice, and Daniel H. Shea.

Mr. Day is also president of the Electric Storage Battery Company which supplies the batteries used in the vehicles of the Electric Vehicle Company. The last-named company has bought from Mr. Riker, personally, all his foreign patent rights, the Riker Motor Vehicle Company having owned only his United States patents. Mr. William C. Whitney and his associates are understood to control both Electric Vehicle Company and the Electric Storage Battery Company.

Current has been turned on at the power-house of the River Falls, Wis., electric light plant. This is a new company which was recently organized to light the streets, business houses and residences of the town.

Industrial Notes

GOLDMARK & WALLACE, New York city, announce that they removed on December 6 to 67 Cortlandt street.

THE MORRIS ELECTRIC COMPANY, 15 Cortlandt street, New York city, has taken the general sales agency for the "O. K." soldering salts, which contain no acids and are made in stick and paste forms.

THE ELECTRIC VEHICLE COMPANY, Hartford, Ct., has received two letters from the proprietors of hotels in Washington, D. C., commenting favorably upon its vehicles, which they have been using for some time past.

THE CROWN WOVEN WIRE BRUSH COMPANY, of Salem, Mass., is selling large quantities of its Crown commutator compound. This compound is said not only to lessen the likelihood of sparking on a dynamo or motor, but prevents wear.

MR. ALBERT PRESTON, Philadelphia, Pa., late of Preston, Cohen & Company, has opened fine offices in the Real Estate Trust Building in that city, for the handling of electric railway supplies, and purposes to make a vigorous campaign in this line.

I. P. FRINK, of 551 Pearl street, New York, makes a specialty of electric lighting of show windows, and is the recognized authority in this branch of the electrical industry. An interesting circular giving valuable information in this respect will be sent on application.

THE WAGNER ELECTRIC MANUFACTURING COMPANY, of St. Louis, has established offices in all the leading cities of this country, as well as in Yokohama, London and the City of Mexico. The foreign department of the company is located in the Havemeyer Building, New York city.

ANY ONE INTERESTED in an alternating-current electric light plant who has not received the little book, "Skepticism," should address the Electric Appliance Company, Chicago. The book is not only very neatly gotten up, but tells, so the publishers enthusiastically state, about the best thing yet in wattmeters.

THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD has issued, through its general passenger agent, circulars and a clipping from the Chicago *Inter-Ocean* relative to the conviction and punishment of two men who had been, until their apprehension, wholesale pass and ticket forgers over several lines of steam railway.

W. E. CALDWELL COMPANY, Louisville, Ky., is sending out its catalogue of tanks, towers and tubs, ranging all the way from a small water receptacle, two by two, to a 100,000-gallon steel tank on a 100-foot all-iron tower. This apparatus is useful in connection with central stations, mines, paper mills, railroads, factories of all sorts, hotels and farm use.

JOHN T. McROY, 302 Broadway, New York, has issued a very neat blotter illustrative of the tensile strength of his vitrified conduits. The blotter is printed in colors and contains Howard Weeden's poem, "At Ease." In the left-hand corner is printed the calendar for the current month of December. Copies will be sent upon application to all interested in underground conduits.

THE PHOENIX GLASS COMPANY, of 15 Murray street, New York city, has long been noted for its artistic arc and incandescent lamp globes and shades. This company has recently, through the medium of the advertising pages of the ELECTRICAL REVIEW, printed its announcement in five languages. As a result it is receiving a large number of foreign orders, and finds the outlook for export business to be particularly promising.

ADOLPHE A. CHAILLET, 476 Ellicott Square, Buffalo, N. Y., wishes to announce that he has resigned his connection with the Shelby Electric Company, as technical manager, and has opened an office as consulting and electrical engineer at the address given above. He also has the agency of the Shelby incandescent lamp in the Buffalo territory, and will remain a director and the technical adviser of the Shelby company.

THE COLLYER INSULATED WIRE COMPANY, of Pawtucket, R. I., will supply free samples and prices to all who are interested in insulated wires and will write to the home office of the company. The Collyer company manufactures the "I. X. L." weatherproof and slow-burning wire and has achieved a highly satisfactory success in this field. All the company's wire products are in accordance with the national electrical code standard.

THE CHASE-SHAWMUT COMPANY, of Boston, Mass., is having great success with its new "Boston" cable clip. The clip is of extraordinary strength and extremely simple in its design. It can be attached to almost any size cable and so tightly fastened that it is impossible for the cable to slip after it is once adjusted. The company states that almost all the large telephone and telegraph companies throughout the country are using the clip with much satisfaction.

THE ROSE POLYTECHNIC INSTITUTE, Terre Haute, Ind., announces that its curriculum is limited to the five courses of engineering mentioned in its catalogue. No partial courses are allowed to any undergraduate but special studies may be taken by qualified graduates of other institutions. Special attention is paid to each student, and in the department of electrical engineering such training is given as will enable the student to cope with all the difficulties presented by the art.

THE BRIDGEPORT BRASS COMPANY, of 19 Murray street, New York city, is selling large quantities of its "phono-electric" wire for the new street railroads that are being constructed throughout the country. This wire, the company states, is particularly strong in its construction, and of great elasticity, so that it will bear a great strain before breaking. The company has several photographs showing parts of the wire where it had met with an unusual strain and still held together without even splitting.

THE WESTINGHOUSE COMPANIES' PUBLISHING DEPARTMENT, Pittsburgh, Pa., has issued an unusually attractive and handsome brochure illustrative of the steam-loop and gravity return system for returning the hot water of condensation from steam pipes to boilers. This system is manufactured by Westinghouse, Church, Kerr & Company, New York. The book contains a large number of fine half-tones showing some of the plants in which the system has been installed. The cover of the book is in heavy, rough, gray paper, handsomely stamped in black and gold.

NORTHERN ELECTRICAL MANUFACTURING COMPANY, Madison, Wis., has been awarded the contract for the Detroit, Mich., municipal electric lighting plant for $35,865. Three bids were considered, those of the Westinghouse, General Electric and Northern Electrical Manufacturing Company, all three being closely figured. When finished, the Detroit plant will be one of the most complete and modern installations in the country, say the manufacturers. The closeness of the bids is believed to indicate that the larger electrical manufacturers have arrived at a more exact basis of cost and are, therefore, basing their figures more accurately than in former years.

EXPANSION—Owing to a constantly increasing demand for its products, the Sprague Electric Company has been obliged to greatly increase the floor space in the New York office, which is now located on three floors of the factory. The New York factory is devoted exclusively to the manufacture of the various lines of interior conduit and appliances which have brought the art of electric wiring to an absolute simplicity. The company operates a still larger plant in Bloomfield, N. J., where are manufactured all the light and power apparatus, such as generators, motors, fans, elevators, hoists, etc. A new branch office will be opened soon, the details of which will be given later.

THE LARGE ADDITION to the machine shop and the new building provided for the brass foundry, boxing and brass polishing departments of the Bullock Electric Manufacturing Company, Cincinnati, Ohio, are nearing completion. When occupied they will so increase the floor space and improve the facilities to such an extent that the capacity of the works will be nearly doubled. Many large contracts have been received recently, from both home and abroad, and the company states that the present outlook for business during 1901 is even better than during the past four years. It has recently issued Bulletin No. 37, which gives a list of the purchasers of Bullock apparatus, shows numerous views in the works and the various types of machines manufactured.

A NUMBER OF COURSES OF INSTRUCTION by mail, of special interest to electrical workers, are offered by the International Correspondence Schools, Scranton, Pa. The electrical engineering course includes instruction in both mechanical and electrical engineering and is intended especially for men desiring to study the design of electrical machinery, either continuous or alternating current. A much shorter course, which includes the electrical instruction of the electrical engineering course, except that the principles and design of alternating-current machinery is optional, is known as the electrical course. The electric power and lighting course is exceptionally popular with linemen, dynamo-tenders, stationary engineers, installation engineers, superintendents and men employed in power-stations supplying current for both lighting and railway work. The electric lighting course prepares students to install and operate electric arc and incandescent lighting systems. The electric railways course treats of the construction and management of electric railways under the storage battery, trolley or third-rail systems. The electric car running course teaches the operation of electric cars and motors from the standpoint of the practical electric railway man. It is also well adapted for men operating electric automobiles, launches, mine locomotives, cranes, elevators or similar machinery. The telephony and telegraphy courses will qualify students for advanced positions in telegraphy and telephony. In each course instruction is carried on by mail. Students are furnished instruction papers and are required to pass an examination on each paper before taking up the next in the course. Instruction in addition to the regular papers is given on any matter which the student finds difficult. The instruction is planned to meet the requirements of men actually engaged in electrical work and how successfully this has been accomplished is shown by the large number of students now holding important positions in electrical industries. The principal of the school of electricity is Robert Baird Williamson, M.E., formerly with the Canadian General Electric Company and later instructor in electrical engineering at Lehigh University.